SCIENTIFIC REPORTS

OF THE

Agricultural Research Institute, Pusa

(Including the Reports of the Imperial Dairy Expert and the Secretary, Sugar Bureau)

1921-22

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
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Scientific Reports of the Agricultural Research Institute, Pusa

(Including the Reports of the Imperial Dairy Expert and the Secretary, Sugar Bureau)

1921-22

REPORT OF THE DIRECTOR.

(S. Milligan, M.A., B.Sc., and W. H. Harrison, D.Sc.)

I. Charge and Staff.

Charge. Mr. S. Milligan held charge of the office of Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, throughout the year.

The post of Joint Director was held by Mr. G. S. Henderson until the 9th December, 1921, when Dr. W. H. Harrison took over charge.

Staff. Mr. F. J. Warth was appointed Physiological Chemist from the 1st July, 1921. He remained in charge of the Chemical Section till the return of Dr. W. H. Harrison from leave on the 24th October, 1921.

On the expiry of leave, Mr. C. M. Hutchinson, C.I.E., resumed charge of the post of Imperial Agricultural Bacteriologist on the 5th October, 1921, relieving Mr. J. H. Walton who reverted as Assistant Agricultural Bacteriologist.

Dr. F. J. F. Shaw officiated as Imperial Mycologist till the 29th December, 1921, when Mr. McRae resumed charge on return from leave. Mr. J. F. Dastur acted as Second Imperial Mycologist during the period with the exception

of a month and a half from the 22nd August, 1921, when he was on leave and Mr. M. Mitra acted in the post.

Mr. T. Bainbrigge Fletcher, Imperial Entomologist, continued in charge of the work in pathological entomology until the 25th June, 1922.

Mr. P. V. Isaac appointed as Second Entomologist (Dipterist) took over his duties on the 26th June, 1922.

The services of Dr. A. P. Jameson, Protozoologist, and Mr. W. A. Davis, Indigo Research Chemist, were terminated on the 16th October, 1921, and 19th May, 1922, respectively, on the closing of their short term agreements.

Mr. R. C. T. Petty, who was appointed Assistant Agricultural Bacteriologist from the 19th November, 1921, died on the 15th March, 1922.

II. Work of the Institute.

Scientific work. The more important work of the Institute is briefly summarized below:—

Botanical Section. The replacement of the country wheats by more efficient varieties of better grain quality evolved at Pusa continues, and it is estimated that in the two chief wheat-growing provinces of India (the United Provinces and the Punjab) over a million acres of improved wheats are now being grown by the cultivators. There is still a great demand for bearded wheats with strong straw and high yielding power, which appears likely to be satisfied by a new series of hybrids now being tested in various parts of the country with encouraging results. The breeding work on tobacco and roselle was continued, and a beginning has been made in the study of the varieties of barley grown in India. Several varieties of linseed which yield considerably more than the ordinary crops have been isolated and an attempt is being made to create types suitable for the alluvium. A promising start has been made with the botanical work in connection with a detailed investigation, under the auspices of the Indian Research Fund Association, of a form of paralysis known as lathyrism—commonly supposed to be due to the long continued con-

sumption of the seed of *khesari* (*Lathyrus sativus*). The work on the physiological aspects of crop production was extended in several directions, and the results are being applied to the solution of practical questions.

Chemical Section. The energies of this Section were mainly directed to a study of the movements of nitrates in the soil and sub-soil with a view to their correlation with seasonal and cropping variations. Work of this type must naturally be spread over several years, but the investigation, so far as it has progressed, shows that the distribution of nitrates through the sub-soil is determined by climatic factors and the physical characters of the sub-soil layers, and that the growth of the crop is in turn controlled to a considerable extent by this distribution. The year's results of the experiment on the windrowing of cane under Pusa conditions were in sharp contrast to those of previous years and confirmed the conclusions drawn from the Peshawar experiments that the period for which the windrowed canes can be stored is determined by the incidence of heavy rain. The determination of carbon-dioxide on grassed and cultivated land was continued. The collection and preparation for publication of methods of analysis recommended in connection with the examination of manures, fertilizers and soils has been taken in hand.

Animal nutrition. The eight months' work on this subject has necessarily been of a preparatory nature. The main line of work in hand is the digestibility of the more common Indian fodders.

Bacteriological Section. The investigation into the losses of nitrogen from cattle dung and urine, referred to in last year's report, indicated that greater losses occurred when these were stored in mixture than when stored separately. The work on the solubilization of rock phosphate was continued. In view of the importance of dispensing with the use of sulphuric acid as a solvent the results obtained by composting are of considerable interest. Similarly the increased rate of nitrification of *mahua* cake (*Bassia latifolia*) by composting with nodule phosphate

alone or combined with soil and sulphur is of immediate practical importance. The vat fermentation work on indigo was continued.

Mycological Section. Appreciable progress was made with investigations into the diseases of paddy caused by *Piricularia*, a sclerotial fungus, and a species of *Cephalosporium*, and *Helminthosporium* diseases of cereals. Preliminary experiments have shown that the smut of *bajra* (*Pennisetum typhoideum*) is amenable to treatment, and further work on a field scale is in progress. Applications of sodium sulphate have been found to have had considerable influence in reducing the incidence of the parasite which causes a stem-rot of jute. Demonstrations of methods of spraying in orchards against fungal diseases of the apple, pear, peach, etc., were continued, and a new sprayer was tried on a commercial orchard, effecting considerable saving in time, labour and material.

Entomological Section. The investigation on borers in sugarcane and other gramineous plants and on the relative immunity of varieties of cotton to boll-worm attack was continued on the lines of previous years. In the wheat experimental plots at Pusa suffering from the attack of an Aphidid, Coccinellid beetles were liberated with good effects, and termites attacking growing sugarcane were checked by the application of crude oil emulsion to the irrigation water. A large cigarette factory, which suffered last year a loss of about seven lakhs of rupees from the activities of the Cheroot Beetle, was recommended a method of fumigation of finished cigarettes with the result that no further complaints have been received. Life-histories of various new insects were studied and steady progress was made in additions to, and arrangement and identification of, the collection of specimens which forms a key to the whole of the information regarding Indian entomology. The work under pathological entomology was continued mainly with reference to Culicidæ, *Ochromyia*, Mallophaga and Anoplura. The sericultural establishment, which had been on a

temporary footing, was closed down from the 1st April, 1922, and most of the staff and apparatus transferred to the Bihar Department of Industries.

Agricultural Section. The permanent manurial and rotational experiments are being continued and expanded in view of the experience gained. The chief result of importance during the year has been the re-establishment, by a single ploughing in of a green manure, of the fertility of a series of plots " phosphated " 5 years ago which had to all appearance through repeated cropping dropped to a lower scale of fertility. The non-phosphated check plots showed no such results. The phenomenon in addition to being one of considerable scientific interest is of the greatest practical importance to agriculturists. The major portion of the farm forms an experiment in mixed farming on a large scale treated in a manner to secure the maintenance of soil fertility.

During the last 10 years the average daily yield of Montgomery cows has increased from $5\frac{1}{2}$ to 9 lb. including dry periods as well as those in milk. On the same basis of calculation, the average daily yield of the cross-bred cows amounted to 15 lb. during the year. The first batch of double cross-bred heifers (F_2 generation) has now come into milk, and on their performances will largely depend the laying down of future lines of work. Two outstanding facts of practical importance have already emerged, *viz.*, the prepotency of the sire in milk production and the shortening of the dry period through weaning the calves from birth.

Imperial Dairy Expert. The problem of the milk supply of large cities like Calcutta and Bombay has received detailed attention by this officer and dairy schemes were drawn out for the production of milk outside the cities. Advice was also given as regards the working of a proposed dairy farm near Ahmedabad, the utilization of the Baroda Palace Dairy as an educational and cattle-breeding centre, the milk supply of Jamshedpur and Rangoon, and the establishment of demonstration dairies, with a suitable milk

pasteurizing and cooling plant, at the Cawnpore, Lyallpur and Mandalay Agricultural Colleges and the Bulandshahar Agricultural School. A sound and organized system of dairy education is, however, the *sine quâ non* of the successful working of the many schemes prepared by this officer, and it is hoped that it will be possible to do something at an early date in the direction of providing a modern dairy college in some part of India.

Sugar Bureau. The principal function of this Bureau is the supplying of information relating to the sugar industry in all its aspects and the promotion of sugar growing in India generally. It has also taken over the testing and multiplication of improved varieties for Bihar conditions. Many of the sugarcane seedlings bred at the Government of India farm at Coimbatore have been found to possess qualities admirably suited to Bihar conditions. A few of these are being multiplied by the " short planting " method for distribution among large growers, and arrangements have been made with a large manufacturer to make mill trials with these canes. The Bureau organized during the year a cable service with all principal sugar markets of the world, the cost of which is wholly borne by the firms taking advantage of the service.

Training. Twelve post-graduate students were under training at the Institute during the year in the following subjects :—

General Agriculture	4
Economic Botany	1
Agricultural Chemistry	1
Mycology	3
Economic Entomology	1
Agricultural Bacteriology	2
	12

In addition, Mr. Hem Singh Pruthi, of the Punjab Entomological Staff, worked in the Entomological Laboratory for a short time, and two students were given a short-course in sericulture.

III. Publications.

Thirteen Memoirs, 31 Bulletins and two Indigo Publications were issued during the year, while over 25 publications were in the press on the 30th June, 1922.

A steady rise in the demand for the *Agricultural Journal of India*, which continued to be issued every two months, and the other publications of the Institute clearly indicates the growing interest taken by the educated section of the community in agricultural matters.

IV. Accounts:

The total expenditure during the financial year ending the 31st March, 1922, was Rs. 7,81,034, as against Rs. 9,84,553 (which included capital expenditure from a special grant of Rs. 2,52,000) during the previous year.

	Rs.
General expenditure of the Institute including the Agricultural Adviser's Office	2,88,707
Botanical Section	59,759
Chemical Section	52,744
Agricultural Section	1,19,181
Mycological Section	48,783
Bacteriological Section	53,450
Entomological Section	57,010
Pathological Entomological Section	16,135
Physiological Chemical Section	24,818
Protozoological Section	19,217
Indigo Research Section	41,230
	7,81,034

The following are the principal items of expenditure under the annual grant of Rs. 10,000 placed at the disposal of the Agricultural Adviser for expenditure on special agricultural experiments :—

	Rs.
Purchase of Daleneoscope	2,668
Cotton experiments	127
Experiments with fibre extracting plant	149
Construction of a butter shed	436
Mosquito experiments	508

The gross receipts during the year from the sale of publications, farm produce, milk and other articles amounted to Rs. 38,822 as against Rs. 30,313 last year.

V. Conference.

The Twelfth Meeting of the Board of Agriculture in India was held at Pusa from the 13th to 18th February, 1922, under the presidency of Mr. S. Milligan, Agricultural Adviser to the Government of India. The meeting was attended by 49 members and 31 visitors, including Mr. G. Anderson, Director of Public Instruction, Punjab; Lieutenant-Colonel J. Matson, Assistant Controller, Military Dairy Farms; Lieutenant-Colonel E. D. W. Greig, Director of Medical Research; Major G. R. Richards from South Africa; and Mr. G. S. Butler, Manager, Cordite Factory, Nilgiris.

REPORT OF THE IMPERIAL ECONOMIC BOTANISTS.

(A. Howard, C.I.E., and G. L. C. Howard, M.A.)

I. Introduction.

The Imperial Economic Botanist held charge of the Section during the year ending June 30th, 1922. As far as funds permitted, a certain number of minor improvements were carried out in the Botanical Area. Three pairs of work cattle were purchased to replace worn out stock. Damage to the extent of about three hundred rupees was done to the departmental buildings by the hailstorm of May 21st, 1922.

Among the advisory duties of the Section, which are now considerable, a visit was paid to the Bhopal State and a report was drawn up on the future work of the Agricultural Department. Four meetings of the Central Cotton Committee were attended. An evening lecture on disease in plants was given at the Victoria Institute, Nagpur, on August 1st, 1921.

The work of the staff continues to be satisfactory and Haji Abdur Rahman Khan, Babu Kashi Ram and Sarup Singh deserve special mention.

II. Wheat.

Seed distribution. For the first time in the history of the Section, it was possible, through the improvement of storage facilities, to carry a few maunds of selected seed over the rains to satisfy some of the more important indents which always come in during the monsoon and at sowing time. The problem of meeting the constantly growing demand for botanically pure seed has, however, not been solved. This will only be possible when the Section possesses its own seed farm when large reserve stocks can be

accumulated and indents can be disposed of without delay. During the year under report, 131 maunds of selected seed, mostly Pusa 12 and Pusa 4, was distributed from the Botanical Area to 56 applicants. A large number of small samples were also despatched through the post to correspondents and investigators overseas. The preliminary results obtained by crossing Pusa 4 with French wheats, referred to in the last report, are being confirmed. Professor E. Schribaux, of the Institut National Agronomique, Paris, writes (letter dated Paris, April 7th, 1922) :— "La 2ème génération de nos croisements de Pusa No. 4 nous a fourni des plants précoces, productives, résistantes à la verse, à la rouille. De plus, le grain produit est de bonne qualité. J'espère que la sélection individuelle que nous abordons cette année ne fera que confirmer nos premières observations." Pusa 4 is exceedingly resistant, under Indian conditions, to yellow rust (*Puccinia glumarum*).

In the last report, an account was given of the various agencies, both official and unofficial, which have been developed in the United Provinces for the spread of improved wheats. This work is now absorbing a large portion of the energies of the Agricultural Department and was referred to by the Director of Agriculture in the Administration Report of 1920-1921 as follows :—

" The cultivation of better yielding varieties of wheat has been permanently established in the United Provinces. It may be regarded as the most successful and definite result that the Agricultural Department has obtained.

" The area under wheats, introduced by the Department, was estimated by my predecessor, Mr. Hailey, at 100,000 acres in 1916 and at 250,000 acres in 1918. The area has now reached a figure at which accurate estimates cannot be made by departmental agency, but it cannot fall short of four hundred thousand acres.

" The Agricultural Department was fortunate in the early days of its development in obtaining Pusa wheats, which are admirably suited to the local conditions, and the Provinces owe a debt of gratitude to Mr. and Mrs. Howard, the Imperial Economic Botanists, Pusa, who introduced them.

"The wheats give an increased yield, when grown under the cultivators' conditions, but their main characteristic is their power to respond to better treatment. This fact is now recognized by cultivators, and is acting as a great stimulus in promoting improved cultivation.

"The largest yield, hitherto recorded, was obtained last year, *viz.*, 37 maunds per acre. During the harvest of the year under review the wheat crop, in many districts, was damaged by early and continuous west winds during the ripening period. This resulted in a much diminished yield of grain, and it is worthy of remark that Pusa 12 gave a fair yield of grain in tracts where other varieties yielded scarcely any.

"The work of the Department in connection with wheat has, as in former years, consisted in maintaining a supply of pure seed from seed farms and seed depôts. The latter are almost entirely stocked with Pusa wheats. During the year under report, 39,560 maunds of wheat seed was distributed to cultivators."

At a moderate estimate the increased return to the cultivators of the United Provinces is at least Rs. 15 per acre. Expressed in money this represents an annual gain of about 60 lakhs of rupees. The Agricultural Department is steadily increasing the number of its seed depôts where the cultivator can purchase the best varieties and the Government have cordially accepted a resolution, moved in the Council, that the ultimate aim should be to establish a seed depôt in every *tahsil*.

In the Punjab, the distribution of Punjab 11, a variety selected by this Section in 1908, has now reached over 600,000 acres. *Thus in the two chief wheat growing Provinces of India over a million acres of improved wheats are now being grown by the cultivators.*

Milling tests. In connection with future shipments of Pusa wheats to Europe, the following technical report, furnished by Messrs. Spillers, London, on May 3rd, 1922, to Messrs. Ralli Brothers, London, is of interest. The samples of Pusa 4 and Pusa 12 were grown at Pusa, the Calcutta Club No. 2 was a mixture of Cawnpore and Fyzabad wheats of the quality usually shipped by Messrs. Ralli Brothers from Calcutta.

" We have pleasure in appending herewith a technical report on three samples of wheat recently received from your goodselves.

	1	2	3
	Pusa 4	Pusa 12	Calcutta Club No. 2
Moisture	10·74	10·48	11·68
Oil	1·86	1·89	1·88
Albuminoids (N × 6·25) .	15·45	12·82	10·02
Digestible carbohydrates .	68·39	70·74	72·50
Indigestible crude fibre .	2·01	2·60	2·48
Ash.	1·55	1·47	1·44
	100·00	100·00	100·00
Wet gluten . . .	41·31	34·64	32·69
Dry gluten . . .	13·89	11·14	7·80
Strength	Strength above the general run of Pusa wheats.	Strength about normal for the general run of Pusa wheats.	Above that of the run of Club Calcutta.

" Both Pusa wheats are very similar in gluten character and not nearly as short and brittle as the gluten of the Calcutta Club No. 2 sample. The Calcutta Club No. 2 sample contains the following percentages of foreign matter:—

Linseed	0·288
Barley	1·325
Peas	0·389
Dirt	0·419
Chaff	0·09
	2·51

" The two Pusa wheats are clean and contain no foreign matter.

" Comparing the wheats reported on above from the miller's point of view, it is considered that all three will have approximately the same flour yield; the superior (actual and potential) strength of No. 1 and to a lesser extent of No. 2 would enable an English miller to use a much larger proportion of No. 1 and of No. 2

wheat in his grist than would be possible with No. 3 and at the same time maintain a given standard of strength.

"From the above report and the general appearance of the wheats submitted, we would express the opinion that these qualities would be acceptable to the millers of the United Kingdom in general."

At the 1921 Royal Agricultural Show at Sydney, New South Wales, two Pusa wheats—Nos. 4 and 107—again took a first prize. Pusa 107 with a bushel weight of 68 lb. was the only wheat in the show which obtained the maximum number of points. Pusa 4 with a bushel weight of $67\frac{3}{4}$ lb. lost half a point on bushel weight but otherwise gained full marks.

Intensive wheat cultivation. Besides the replacement of the country wheats by more efficient varieties of better grain quality, there is another direction in which this crop can be improved. This is by means of intensive cultivation. In striving to increase markedly the production of grain per acre under Indian conditions, where the growth period is very short, the investigator has to overcome a formidable difficulty, namely, the growing tendency of wheat to lodge as the soil is enriched. Vital as an adequate supply of combined nitrogen is to any increase in wheat production, its use always increases the amount of foliage and slows down the rate of growth. Loss of standing power and poor grain are frequent results. This difficulty can be overcome by the judicious selection of early varieties with strong straw and sparse foliage for intensive cultivation. The enrichment of the soil in such cases increases the foliage and prolongs the growth period but if the right variety is selected there need be no loss of standing power. Pusa 4 is proving an excellent variety for this purpose. During the current year, a yield of 37·5 maunds to the acre was obtained in a season when the soil moisture was short and yields were low. This is the highest yield so far obtained in the Botanical Area.

Bearded wheats. In some parts of India there is a great demand for bearded wheats with strong straw and

high yielding power. The cultivator in these cases wants a wheat like Pusa 12 which however is bearded and which is not attacked by birds and wild animals if left standing in the field at harvest time. This demand is likely to be satisfied by a new series of hybrids which are now being tested in various parts of India. The results obtained by Mr. T. R. Low, Deputy Director of Agriculture, Central Circle, U. P., at Kalianpur and Hardoi, and by Mr. G. Clarke, Agricultural Chemist to Government, at Shahjahanpur, are given in the following table. It will be seen that the new Pusa bearded wheats are likely to equal if not exceed Pusa 12 in yielding power.

TABLE I.

Trials of bearded Pusa wheats at Kalianpur, Hardoi and Shahjahanpur, 1921-22.

Variety	Kalianpur	Hardoi	Shahjahanpur	
	m. s.	m. s.	m. s.	
Pusa 12	29 6	25 5	23 15	The Shahjahanpur yields were obtained on poor *bhur* soil. Pusa 12, grown after sugarcane in trenches, gave 31 mds. per acre at this station in 1922.
Pusa 51	28 26	25 0	22 0	
Pusa 52	31 36	22 29	24 0	
Pusa 54	33 19	22 11	22 0	
Pusa 55	30 30	—	—	
Pusa 56	32 25	—	—	
Pusa 59	30 25	—	—	

In the Central Provinces two bearded wheats, Pusa 100 and Pusa 101, are giving good results.

III. OTHER CROPS.

Tobacco. The increased demand for seed of Pusa 28 continues. During the year, seed for over 60,000 acres was asked for and supplied. More indents are being recei-

ed from Burma. In the Kistna delta, very good samples of leaf were obtained in spite of the unfavourable season. The breeding work in progress on this crop was continued.

Fibres. Some progress was made during the year in the breeding work on Roselle. A stock of seed of *Hibiscus cannabinus*, Type 3, is being maintained.

Oil seeds. The isolation and classification of the unit species which make up the Indian linseed crop was completed and the results are being prepared for publication. The types fall into two main classes, one suitable for the soils of the Peninsula, the other for the alluvium. A beginning has been made in testing the black soil types on the various farms in the Central Provinces. Similar work on the alluvium is in progress. Several types, which yield considerably more than the ordinary crop, have been isolated and the work promises to yield results of economic importance. Among the 122 types isolated, no large seeded form with a root system suitable for the alluvium has been found. Breeding work has been started to create this and other desirable types.

A collection of unit species of safflower has been handed over to the Bombay Agricultural Department for trial at Poona.

Gram. A small seed supply of the more promising types was maintained but the Botanical Area is too small to do justice to this crop.

Barley. A beginning has been made in the study of the varieties of barley grown in India.

With the advent of post-graduate students, each of whom will require a certain amount of land, the stage has been reached when the economic work of the Section will have to be curtailed. From the point of view of the agricultural development of India this will mean a further loss of efficiency and a slowing down of the rate of progress. The fact that the laboratory where the physiological work is being done is about a mile from the Botanical Area involves a great deal of loss of time and energy. To obviate these

disadvantages and to solve the problems of seed supply and want of land, proposals have been submitted for removing the botanical work to the newly acquired area of 160 acres and for erecting a laboratory there. The capital required is $2\frac{1}{2}$ lakhs of rupees. This money would remove all our difficulties and greatly increase the usefulness of the Section.

IV. Physiological Investigations.

The current work on the physiological aspects of crop production has been extended in several directions during the past year and now absorbs a large portion of the energies of the Section. Results of great promise are being obtained, some of which are being applied to the solution of practical questions.

Soil aeration. The importance of soil aeration in crop production, which has been emphasized for some years in previous publications, is now being recognized all over the world, particularly in the United States. In that country, the investigation of the part played by oxygen and carbon dioxide in the soil atmosphere is being energetically pursued in many directions. One result has been the publication of a monograph by Dr. Clements, of the Carnegie Institution of Washington, on soil aeration in which the literature dealing with the respiration of roots and with anærobiosis has been analysed in detail. Prominence has been given to the investigations on this subject carried out in India at Dehra Dun, Pusa, Quetta and Coimbatore. A good deal of this work is finally summed up in the following words :—

" The results of field studies of aeration are in complete agreement with those obtained from physiological investigations as to the basic importance of oxygen for root activity and the injury wrought by the accumulation of carbon dioxide. The detailed significance of the lack of oxygen and the abundance of carbon dioxide as ecological factors is discussed in connection with bog xerophytes and soil toxins. Here it will suffice to point out that field research has approached the problem of an oxygen deficit from four different angles, and that the results and conclusions are all in essential

accord. The agricultural approach has been made by Soraner, Deherain, Wollny, Brizi, Ehrenberg, Balls, Harrison and Aiyer, Howard and Howard, Main and Allan, and that of forestry by Vonhausen, Bohm, Mangin, Hesselmann, Bernbeck, Hole and Singh, and Coventry. Pathological considerations have entered into many of the studies, but they have received especial attention at the hands of Sorauer, Hartig, Mangin, Howard, and Graves, while the ecological outlook has been represented by Warming and Clements."

After considering the work of Widstoe and the recent water saving experiments carried out at Quetta, Mirpurkhas, Gungapur, Haripur, Sargodha and Shahjahanpur, Dr. Clements concludes:—

"It appears almost certain that the common practice in irrigated regions involves the use of too much water, with the consequent economic losses. Not the least of these is the necessary restriction of irrigation systems to a smaller territory than should be the case, which results in a serious limitation of opportunity and production. Throughout the western United States it is a fortunate system that does not face an annual or periodic deficit, while the extent of new reclamation projects must unfortunately be determined by the existing practice rather than by the optimum duty of water. As a consequence it would seem an indispensable task of every great system installed or to be installed, to determine the optimum use of water and to take steps to see that everyday practice conforms to the findings."

Opportunities of basing the details of distribution on the optimum duty of water and on the maintenance of the natural fertility of the soil are about to occur in India in the case of the Sarda Canal in Rohilkhand and Oudh and the Sukkur barrage in Sind.

In Sweden, a monograph entitled "Luftväxlingen i marken som ekologisk faktor" (Soil ventilation as an ecological factor) has been published by Dr. Romell in the *Meddelanden fran Statens Skogsförsöksanstalt*, 19, 2, 1922. In this paper, of which an abstract in German is appended, the Pusa investigations on soil aeration are discussed in considerable detail.

During the rains of 1921, a year of short rainfall, interesting results on the influence of aeration were obtained

with cotton grown in Pusa soil in lysimeters. As was expected from the geographical distribution of this crop in India, the cotton plant is exceedingly sensitive to poor soil aeration and is therefore suitable for experiments on this subject. Useful information was also obtained in the case of maize, *sanai* (*Crotalaria juncea* L), linseed and gram.

Besides the work on plants grown in lysimeters and in pit cultures, laboratory investigations are in progress on the effect of the various factors involved in soil aeration.

The effect of grass on fruit trees. The investigation of the factors involved in the deleterious action of grass on fruit trees, which was commenced in 1907, is now almost complete. The earlier results were published in 1910 in *Bulletin No. 16 of this Institute.* To clear up this question, a special plot was laid down in 1914-16 in which a single variety of the following fruit trees—plum, custard apple, lime, loquat, mango, litchi, guava and peach—was grown under clean cultivation, complete grass and grass with aerating trenches two feet deep and one foot wide filled with broken bricks. It appeared probable that the harmful effect of grass was due to poor soil aeration and that the provision of aeration trenches would partially overcome this factor. The growth results were in accordance with expectation and in 1915 (*Pusa Bulletin No. 52*, p. 23) it was suggested that the deleterious effect of the grass was probably due to carbon dioxide in the soil atmosphere. The soil gases in the three plots have now been periodically examined by Mr. Jatindra Nath Mukherji, First Assistant to the Imperial Agricultural Chemist, for three years—1919, 1920, 1921—and extremely concordant results have been obtained. The figures for 1919 were published in the *Mem. of the Dept. of Agr. in India* (*Bot. Ser.*), XI, 1920, pp. 5 and 6, and are reproduced in Table II. The results of 1920 and 1921 confirm those of 1919. The amount of carbon dioxide was greatest in the grassed plot, least in the cultivated and intermediate in the trenched plot. During the rains, the proportion of carbon dioxide rose considerably particularly in the plots under grass.

TABLE II.

Carbon dioxide in the soil gas, Pusa, 1919.

Month	Rainfall in inches	Percentage (by volume) of carbon dioxide in the soil air		
		Grassed plot	Grassed but partially aerated by trenches	Cultivated plot
January	1·29	0·444	0·312	0·269
February	0·02	0·472	0·320	0·253
March	0·02	0·427	0·223	0·197
April	1·36	0·454	0·262	0·203
May	0·68	0·271	0·257	0·133
June	2·21	0·341	0·274	0·249
July	14·78	1·540	1·090	0·304
August	5·54	1·590	0·836	0·401
September	5·11	1·908	0·931	0·450
October	1·89	1·297	0·602	0·365
November	—	0 853	0·456	0·261

These results confirm in a very striking way the suggestion made seven years ago that carbon dioxide would be found to be a factor in the case. A number of other matters are involved in the harmful effect of grass on trees which will be dealt with in future publications.

Root development. The investigation of the root systems of fruit trees under grass and clean cultivation has suggested that similar work is needed in the case of monsoon crops. This was commenced in 1921 with maize and *juar* (*Andropogon Sorghum* Brot.) and has been continued on these crops during 1922 and also on *sanai* and *rahar* (*Cajanus indicus* L.). We hope to publish some of these results during the ensuing cold weather. These indicate that the facts relating to root development are of far greater significance in agricultural practice than has hitherto been supposed.

Lucerne. One practical application of the investigations on soil aeration is being worked out in the case of lucerne. This was referred to in the last report and the work has since been developed considerably. The method of cultivation on flat beds, two feet wide with irrigation furrows one foot wide between the beds, has again given excellent results. The details of this method (by which the amount of irrigation water needed from sowing time in October to the rains is reduced to a minimum and by which soil aeration and surface drainage are improved during the monsoon) are being perfected and the yield of fodder has been considerably increased. In spite of the fact that nearly forty inches of rain fell at Pusa during June and July 1922, the stand at the time of writing (August 3rd) is still vigorous and healthy. The crop sown on October 20th, 1921, has given eight cuts up to July 11th, 1922, the total green weight of which was approximately 70,000 lb. per acre. In these preliminary experiments, the lucerne was only cut when required for cattle food and no effort was made to obtain the maximum yield. During the following season, arrangements are being made to grow one acre of lucerne on the new intensive method and to raise the maximum possible crop from this area. The details are likely to be of use to cultivators in the neighbourhood of large cities where a ready market exists for this fodder for dairy cattle and transport animals.

Actual trials have shown that lucerne hay can be stored at Pusa without loss or damage during the rains either loose or baled. A small quantity of this hay increases the palatability of *bhusa* during the monsoon even in the case of shy feeders.

There is one drawback to the extended cultivation of lucerne in North Bihar, namely, the seed supply. So far this crop has not been induced to seed freely at Pusa. Copious flowering was obtained this year in the case of the second year crop but the amount of seed obtained was very small. Further experiments are in progress on this point with the object of discovering the factors on which seed

formation really depends. It is fortunate that lucerne seeds readily in the Punjab and parts of the United Provinces. The difficulties in organizing the seed supply will therefore be much less than in the case of berseem.

Lathyrism. Under the auspices of the Indian Research Fund Association, a detailed investigation of a form of paralysis known as lathyrism—commonly supposed to be due to the long continued consumption of the seed of *khesari* (*Lathyrus sativus*)—is now in progress. The chemical work is in the hands of Dr. Simonsen, Forest Chemist at Dehra Dun; Colonel Harvey, C.I.E., Director of the Research Institute at Kasauli, is responsible for the pharmacological investigations, while the botanical work has been offered to us. As it appeared from an examination of the literature that *khesari* might be capable of forming poisonous alkaloids under certain conditions and the whole subject appeared well worthy of investigation from the point of view of vegetable physiology, the invitation to take up this work was gladly accepted. The investigations commenced in August 1921 when steps were taken to collect samples of ordinary bazaar seed from the various localities in the Central Provinces, Bombay, Sind, the Punjab, United Provinces and Bihar and Orissa where lathyrism is known to occur. Thanks to the prompt assistance of many officers of the Agricultural Department and others, a large number of samples were obtained in time for sowing in October. In addition, seed from certain villages near Pusa, where the disease is common, was also sown. The various sets of seed were not pure but contained a number of weeds and other admixture. All foreign seeds were picked out before sowing and planted separately alongside the *khesari* with which they were mixed. In all, thirty samples of this crop were sown.

The method of pollination of *khesari* was investigated and found to agree with the details published in Knuth's *Handbook of Flower Pollination* which relate to the European varieties of the species. Covered plants set seed readily, a fact which will greatly facilitate the isolation

of the various unit species. A large number of single plants were selected from these cultures and from the leguminous weeds which occur in this crop. These will form the basis of next season's investigations.

During the progress of this preliminary work, samples of *khesari* were supplied to Dr. Simonsen and to Colonel Harvey for their experiments. These were obtained from Sakri, a village near Pusa, where lathyrism is common. In all cases the results were negative. Dr. Simonsen discovered no traces of alkaloid in *khesari* while the feeding trials at Kasauli with Guinea pigs and pigeons yielded no positive results. We then suggested that the seed of a leguminous weed, which occurred in all the samples of *khesari* obtained from localities where lathyrism is common, should be examined. This is locally known as *akta* and is apparently *Vicia sativa* L. Alkaloids were at once found by Dr. Simonsen in this seed, a large quantity of which has been collected and despatched to Dehra Dun and Kasauli for further investigations. Storage experiments with *khesari* are also in progress with the view of discovering whether any alkaloids are developed by varying the conditions under which the seed is kept. The influence of the environment on the chemical composition of the seed is also being investigated. So far, the most promising line of advance appears to be the intensive study of the various leguminous weeds met with in *khesari*. This is being developed as rapidly as possible.

Apart from the results obtained on the cause of lathyrism, this investigation has afforded further confirmation of the part played by root development in disease resistance. Shortly before the flowers appeared, it was observed that certain of the *khesari* cultures were attacked by green-fly (*Aphides*) while others were immune to the pest. Between these two extremes other cultures were only slightly affected. Investigation of the root system showed that there was a clear connection between root development and the degree of infection. The cultures attacked by green-fly possessed a sparse root system with a tendency to root

deeply. Those which were immune showed a vigorous development of surface roots while those attacked to a slight extent showed an intermediate root development. The diseased cultures all came from the black soils of the Peninsula; those immune to green-fly were from the Indo-Gangetic alluvium, while the intermediate cultures came from certain villages in the Allahabad District where transition types of soil occur. It is hoped that during the coming year this interesting subject will be explored in greater detail. The results already obtained indicate that the plant must be in the right condition before this pest can make use of it.

V. Programme and Publications.

Programme, 1922-23. Investigations, on the lines indicated in the annual reports and in the publications of the Section, will be continued on the following crops—cereals, tobacco, fibre plants, pulses, oil seeds, fodder crops and fruit—and on soil aeration and root development.

Publications. The following papers were either printed or accepted for publication during the year :—.

1. Report on Economic Botany for the Board of Scientific Advice, 1920-21.

2. The wheats of Bihar and Orissa (with Haji Abdur Rahman Khan). *Mem. of the Dept. of Agr. in India* (*Botanical Series*). (*In the press.*)

3. Disease in plants. *Agri. Jour. of India*, XVI, 1921, p. 626.

4—9. The articles on Deccan oder Ambari-Hanf, Sabdariffa-Hanf, Indischer Sunn-Hanf, Kugelfrüchtige Jute, Langfrüchtige Jute and Sesam in the new edition of Vol. V of *Die Züchtung der landwirtschaftlichen Kulturpflanzen* edited by Professor Dr. C. Fruwirth, Vienna.

10. Post-graduate training in Agriculture. A paper submitted to the Committee of Directors of Agriculture and heads of sections of the Pusa Institute which met at Pusa on February 13th, 15th and 18th, 1922.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(W. H. Harrison, D.Sc.)

I. Administration.

Mr. F. J. Warth was in charge of the Section until 24th October, 1921, when I took over the office on return from long leave.

II. Education.

Mr. K. Warrior, a student from Cochin State, completed his course of training in agricultural chemistry in June 1922.

III. Meteorology and Drain-gauges.

The usual meteorological and drain-gauge records were maintained, and, in addition, a recording hygrometer was installed. The records of the latter should prove valuable.

IV. General analytical work and assistance given to other Sections.

A. The following samples were analysed and reported upon during the year under report:—

Soils	16
Manures	23
Feeding stuffs	17
Sugarcane	19
Sugar-beet	42
Milk	326
Cream	1
Cotton seed	24
Indigo	10
Waters	20
Total	498

Of the soils, eight were received from the Andaman Islands, four from Kotah State and two from Kapurthala State.

Five samples of wheat were sent for analysis by the Secretary to the Agent to the Governor-General in Baluchistan and the 42 samples of sugar-beet were analysed at the request of the Agricultural Officer, North-West Frontier Province.

B. The following assistance was rendered to other Sections :—

Agricultural Section. Eleven samples of manures, one sample of cream and 326 of milk were reported upon.

Indigo Research Section. One sample of manure was analysed.

Cotton Specialist. Twenty-four samples of cotton seed were reported upon.

Bacteriological Section. One sample of common salt and four samples of indigo were analysed.

Sugarcane Expert. Thirteen samples of sugarcane were examined.

Sugar Bureau. The analytical control in connection with the testing of the efficiency of the Honolulu Cane-crushing Mill was carried out by this Section and, in addition, two samples of manures and six of sugarcane were reported upon.

V. Methods of Analysis.

(*a*) Consequent upon the resolutions passed at the Second Meeting of Agricultural Chemists, considerable attention has been given to the collation and preparation for publication of recommended methods of analysis in connection with the examination of manures, fertilizers and soils. These will be submitted to the ensuing conference for final approval.

(*b*) *The accurate determination of the carbon-dioxide present as mineral carbonates in soils.* The amount of organic carbon in a soil is usually determined by deducting the CO_2 present as mineral carbonate from the total

CO_2 obtained by complete combustion. The amount of organic carbon in Pusa soils is very small compared to the amount present as carbonate, and, consequently, in order to obtain reliable values for the former it is necessary to determine the latter with very great accuracy.

A method of estimation was evolved by Mr. Sanyal which satisfied all requirements. The soil carbonates are decomposed by acid *in the cold* in a flask with a specially designed mercury-sealed stirring attachment, and, after the decomposition is complete, the CO_2 is driven off by means of hydrogen generated in the flask itself, and absorbed in the usual manner in U tubes.

A full description of the apparatus and method of operation is being prepared for publication.

(*c*) *Phosphoric acid estimation.* The main objection to the American 1919 method of estimating P_2O_5 in soils and fertilizers is that the amount of molybdate solution employed must be regulated according to the amount of P_2O_5 present. This is inconvenient in practice because, frequently, the value is not known except between wide limits. Consequently, a comparative study of three different methods was carried out, namely, with (*i*) the American 1919 process, (*ii*) the Pusa method, and (*iii*) Prescott's method (*Jour. Agri. Sci.*, 1914).

It was found that Prescott's method answered very well provided the temperature remained low but, at the temperature prevailing in the laboratory during the hot season, the method could not be considered reliable as there was considerable risk of molybdic acid separating with the phosphomolybdate precipitate.

A comparison was then instituted between the American and the Pusa methods using a constant volume of reagent with varying amounts of P_2O_5. As a result it was found, when the data obtained was utilized to calculate the P_2O_5 content of the standard solutions from which the test solutions were made, that the Pusa method gave concordant results, whereas the American method gave decreasing values with increasing amounts of P_2O_5. In

addition, it was found that the presence of ferric chloride does not interfere with the Pusa method, which also allows considerable latitude in the temperature at which precipitation is carried out. The latter would, therefore, appear to be the most convenient for use in India.

VI. Sugarcane.

Mr. Sanyal again continued the experiments on the windrowing of cane under Pusa conditions. Canes (var. Maneria) from $\frac{1}{16}$ acre plots were windrowed on 23rd December, 1921, and again on 23rd January, 1922, and samples were drawn at intervals and analysed.

During the previous season the windrowed canes were exposed to practically no rain and were found to be in good condition one month later. By way of contrast, the windrowed canes during the season under review were thoroughly wetted by heavy falls of rain, and in both instances deterioration of the cane was definitely and immediately established.

It is also noteworthy that the canes windrowed in December 1921 received a total of 0·85″ of rain and showed much more marked deterioration than those windrowed on 23rd January which only received 0·52″. This is shown in the following table :—

	Dates of analyses	Rainfall during period of windrowing	Per cent. juice	Juice composition		
				Per cent. sucrose	Per cent. glucose	Brix
Canes windrowed on 23-XII-21.	23-XII-21	0·85″	63·98	13·09	0·95	16·10
	2-III-22		54·84	8·74	7·70	20·23
Canes windrowed on 23-I-22.	23-I-22	0·52″	62·99	14·43	0·66	17·15
	3-III-22		56·96	11·06	5·16	19·28

This year's results are, therefore, in sharp contrast to those of previous years and confirm the conclusions drawn from the Peshawar experiments, that the length of time

windrowed canes can be stored is determined by the incidence of heavy rain.

VII. Examination of Soil Gases.

Mr. Mukherji continued his investigation into CO_2 content of the grassed and cultivated plots in the Botanical Area and has confirmed his previous results.

The soil atmosphere of the grassed plot is uniformly much richer in CO_2 than that of the cultivated plot, and this difference is most marked during the monsoon months. The values obtained during the year 1921 are given in the following table :—

Variations in the CO_2 content of soil gases, 1921.

Month	Rainfall in inches	Per cent. CO_2 in grassed plot	Per cent. CO_2 in grassed plot partially aerated by trenches	Per cent. CO_2 in cultivated plot
January	nil	0·375	0·294	0·247
February	0·51	0·331	0·282	0·248
March	0·32	0·315	0·302	0·233
April	0·69	0·514	0·430	0·315
May	0·20	0·374	0·322	0·277
June	2·73	0·448	0·421	0·296
July	7·64	1·421	1·219	0·378
August	14·11	2·280	1·648	0·542
September . . . . „	15·20	1·620	1·206	0·442
October	1·44	1·270	0·805	0·300
November	nil	0·873	0·513	0·264
December	nil	0·669	0·373	0·273

It is evident that the very great increase in the CO_2 of the grassed plots during the monsoon months is associated with fairly high temperatures and heavy rainfall, and the conclusion is drawn that it is due to the decomposition of

the organic detritus introduced into the soil from the roots of the grass.

In order to test this conclusion two plots of ground were selected in the Pot-culture House compound both of which were kept grassed over, but of which one was irrigated throughout the hot season, the other remaining under normal conditions. Before commencing the experiments the CO_2 content was determined and found to be 0·474 per cent. in No. 1 and 0·494 in No. 2. The results obtained subsequent to commencing the irrigation of plot No. 1 were as follows:—

Date	Plot I irrigated	Plot II unirrigated
April 7th	0·984	0·441
,, 12th	0·864	0·410
,, 24th	1·000	0·435
May 8th	1·002	0·364
,, 20th	0·819	0·335
June 2nd	0·779	0·349

It may, therefore, be taken as clearly demonstrated that the effect of keeping plots grassed over is to enormously increase the CO_2 content of the soil gases during periods of rainfall. As the action of excess of CO_2 in the soil in retarding plant growth has been demonstrated by several observers, it is to this cause that the poor growth of the trees in the grassed plots of the Botanical Area must be ascribed.

Apart from the effect of the grass in increasing the CO_2 content, another factor is involved. From a determination of the moisture content of these plots it was found during the dry season that the value in the grassed plot becomes as low as 1 per cent. and that in the grassed and trenched plot 1·3 per cent. whereas the value in the cultivated plot is 5·5 per cent. Similar differences in the value of the nitric nitrogen content were also found.

VIII. The Soil of the Experimental Area.

The investigation into the patches of good and bad cropping in certain of the fields of the Experimental Area has been continued, and it is becoming evident that there is some correlation between the character of the cropping and the character of the soil found in the various sub-soil layers. The investigation is being continued on these lines, and particular attention is being paid to determining the relative amounts of colloids in the layers.

IX. The Movements of Nitrates in the Soil and Sub-soil.

The energies of the Section have mainly been directed to a study of the movements of nitrates in the soil and sub-soil with a view to correlate them with seasonal and cropping variations. Work of this type must naturally be spread over several years in order to ensure the conclusions arrived at being valid, and, consequently, a detailed reference to the results obtained hitherto is not at present desirable. Still there are several broad features which are, even now, already prominent and reference can be made to these.

In carrying out these investigations four small plots were selected in different fields so that wide variations in the character of the sub-soil were embraced. At intervals borings to a depth of nine feet were made in the plots and the amount of moisture and nitric nitrogen in each six-inch section determined.

The first borings were made towards the end of September 1921, immediately following a period of heavy rainfall due to a late monsoon, and the amount of nitrate present in the soil was found to be small. The distribution of the nitrate through the column of sub-soil was very irregular, depending upon the character of the several layers. Where the whole column was of open texture the distribution was fairly uniform, but the quantity was small, due evidently to the leaching out of the sub-soil. On the other hand, the presence of layers of close texture was evidenced

by a marked concentration of nitrate in this and the neighbouring layers immediately above it.

During the ensuing period of dry weather nitrification occurred in the surface soil, but the distribution and quantity in the sub-soil layers was not materially affected until the cold weather crop was fairly mature.

It was noticeable that the young crop throve well until the nitrate in the soil layer was used up, and when this occurred a period followed during which the crop was yellow and obviously ill-nourished. In January, however, the crops assumed a healthy appearance, and it was found that the nitrate in the lower layers was being utilized. This continued until the crops were mature but the lowest depth to which the nitrate was utilizable appeared to depend upon the character of the sub-soil layers. In the plots where the layers were uniformly of an open character the nitrate was utilized to a considerable depth, but in the other plots the depth was determined by the presence of a layer heavy in character.

After harvest, and until the advent of the monsoon, there was considerable surface evaporation from the plots and this resulted in the nitrate layer, in those plots which showed any marked zone of concentration, moving towards the surface. This movement could not be traced with any degree of certainty at depths below four feet, and this fact becomes of great importance when the downward movement during the monsoon is under consideration.

A heavy hailstorm towards the end of May caused considerable nitrification to occur in the soil, and with the advent of heavy rainfall on 4th June, the nitrate thus formed was carried downwards into the top layers of subsoil. By the middle of July the nitrate layer had been washed into the deep sub-soil in the open plots and had reached the heavy layers in the others. In the latter cases it was noticeable that the quantity of nitrate in the column had been considerably reduced showing that, even in these conditions, much nitrate had been carried into the deep layers outside the range covered by the investigation.

A diagram (Plate I) giving a few of the determinations obtained is attached to this report and this shows the main points referred to above.

The investigation, so far as it has progressed, shows that the distribution of nitrates through the sub-soil is determined by climatic factors and the physical characters of the sub-soil layers, and that the growth of the crop is in turn controlled to a considerable extent by this distribution. The extent to which these controlling factors can be modified by agricultural operations is a subject for future investigation.

X. Programme of work for 1922-23.

Major subjects.

1. Continuation of the investigation into the amount and nature of drainage water from cropped and fallow land.

2. The influence of manurial treatment of the soil in the composition of crops.

3. The mode of action of phosphatic manures in calcareous and non-calcareous soils.

4. The changes occurring during the windrowing of cane.

5. The movement of nitrates in Pusa soil and the availability of sub-soil nitrate for crop production.

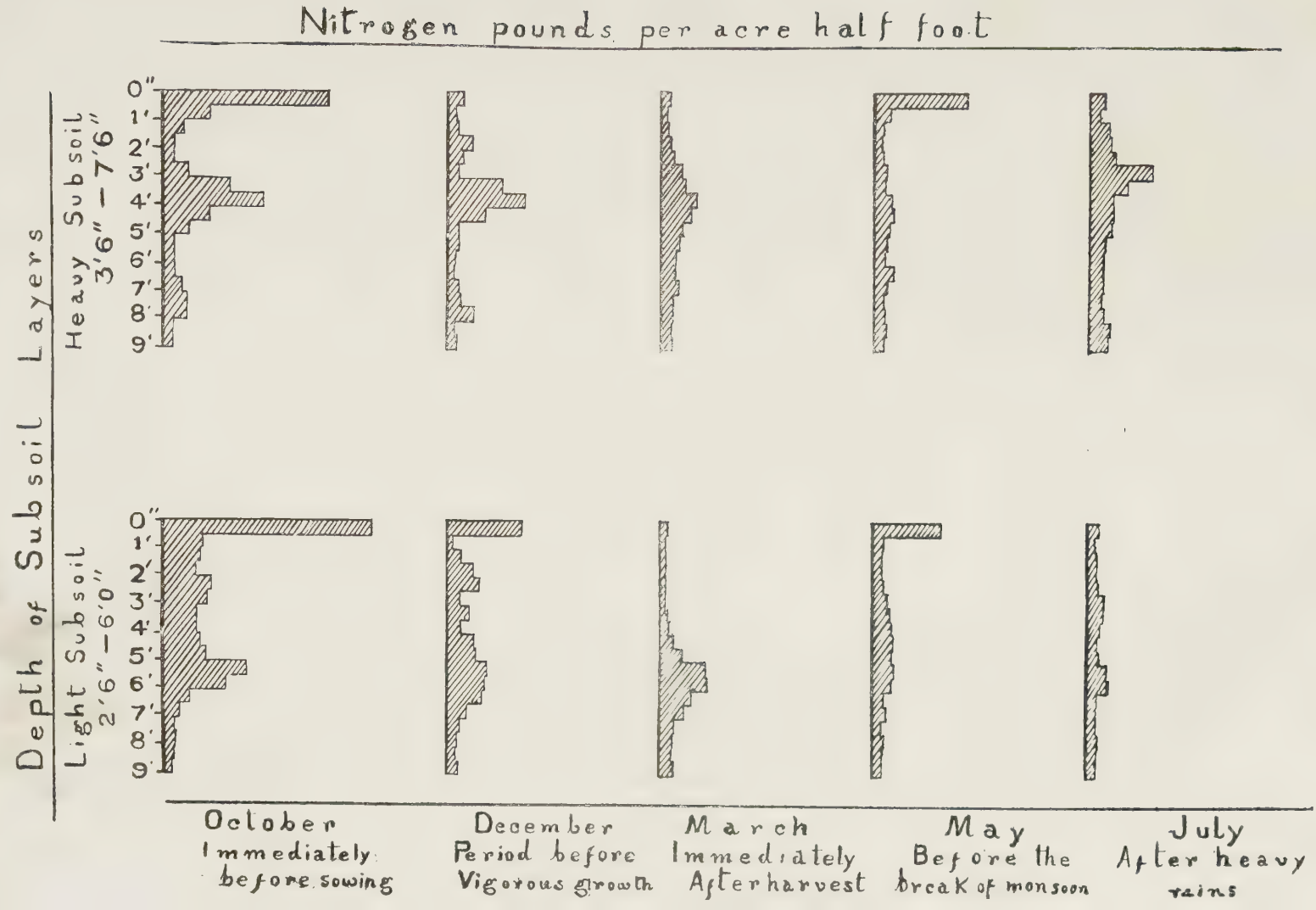
6. A study of the chemical and physical factors involved by the combined application of green manures and superphosphate to Pusa soil.

7. The formation of carbon-dioxide in soils and its effect on crop developments.

Minor subjects.

1. A comparison of the accuracy of various analytical methods.

2. Analytical work required by other Sections.


Nitrogen pounds per acre half foot
Depth of Subsoil Layers
Heavy Subsoil 3'6" – 7'6"
Light Subsoil 2'6" – 6'0"
0" 1' 2' 3' 4' 5' 6' 7' 8' 9'
October
Immediately before sowing
December
Period before Vigorous growth
March
Immediately After harvest
May
Before the break of monsoon
July
After heavy rains

XI. Publications.

Sanyal, P. B. . . The plant *Carica papaya* and its enzyme. *Agri. Jour. India*, XVI, Pt. 5, 1921.

Warth, F. J. . . Report on Agricultural Chemistry, 1920-21, for the Board of Scientific Advice.

REPORT OF THE PHYSIOLOGICAL CHEMIST.

(F. J. Warth, M.Sc., B.Sc.)

I. Charge and Staff.

I assumed charge of the duties of Physiological Chemist on 1st July, 1921, but the Section actually started working on 24th October, 1921, when I was relieved of the additional duties of the Imperial Agricultural Chemist.

The laboratory staff consists at present of one senior assistant (transferred from the staff of the Imperial Agricultural Chemist), one junior assistant recruited on 19th January, 1922, and one probationer. To enable a start to be made, an additional assistant has been lent by the Chemical Section. For a staff to deal with the important work in the cattle stalls there is at present no budget provision. A temporary fieldman has, however, been recruited for this branch. If this work is to be carried on efficiently a permanent staff will be required to deal with it.

II. Training.

Before analytical work could be undertaken the junior assistant and probationer were given a course on routine analysis such as is required in this laboratory. The fieldman also received a training in his duties.

III. Laboratory Work.

Preliminary enquiries have been carried out in the following directions :—

1. *Testing of methods.* Tests have been carried out with reference to—

(*a*) Processes for determination of crude fibre.
(*b*) Processes for estimation of cellulose.
(*c*) Estimation of accuracy of organic N determinations.

(*d*) Elimination of sampling errors in the examination of excreta.

(*e*) Experiments on the preservation of fæces for the preparation of composite samples. As a result of these experiments a great saving of labour and chemicals has been effected.

All this work was a necessary preliminary to cattle-feeding experiments. The results obtained from it have already been and will continue to be of the greatest use in all feeding experiments.

2. *Experiments on the determination of pepsin soluble N.* The object of this work is to obtain supplementary information on proteid digestion. The experiments in progress at present are concerned with the elucidation of certain discrepancies in the process, in order to increase its utility.

3. *Analysis of Indian foodstuffs.* Under this head the first work to be undertaken has been the collection and analysis of *jowar* (*Sorghum*) samples at different stages of development.

The samples in hand represent typical crops from Madras, Bombay, Punjab and Central Provinces. Up to date 68 analyses have been completed. Arrangements are in progress for the collection of typical samples from other provinces.

4. *Analyses in connection with feeding trials.* The following analyses were carried out in connection with feeding trials :—

Complete analyses of foods, fodder, etc. . .	35
Additional moisture and N determinations .	257

IV. Feeding Trials.

A small trial stall for feeding experiments was completed on 20th December, 1921, and fitted out with the necessary apparatus and utensils which were procured from Calcutta.

In this shed after the routine procedure had been worked out four preliminary feeding tests were made.

The results obtained from these feeding trials show fairly clearly that the proteid requirements for maintenance of the indigenous breed of Bihar cattle is remarkably low, whilst the net energy requirement does not differ materially from that required by European breeds.

There is also some evidence of a seasonal factor in N assimilation. Numerous data bearing on these points have been obtained. It is, however, at present too early to draw definite conclusions from them. Their significance must await corroboration by further tests. Still these preliminary results are significant in one respect. They show that these animals have adapted themselves to a wide nutritive ratio such as may be obtained from crop residues and other coarse fodders. They show in fact the nature of the cattle food generally available in this part of the country. In any attempt to introduce new blood or in selection of the indigenous breeds for the purpose of obtaining better cultivation this point will require to be considered.

Finally, in the course of these trials entirely satisfactory procedures suited to local conditions have been worked out. Based on this experience permanent digestion stalls have now been erected and plans prepared for the early completion of other essential adjuncts.

Although much of the work during the period under report has necessarily been of a preparatory nature, it has been possible at the same time to obtain a certain amount of valuable information on animal nutrition.

V. Programme of work for 1922-23.

Major subjects.

1. Determination of the digestion co-efficients of important Indian coarse fodders and concentrated foodstuff.

2. The study of the nitrogen metabolism of Indian cattle.

3. A study of the chemical methods involved in the above enquiries.

Minor subjects.

1. Composition of Indian foodstuffs.
2. Study of silage production.

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST.

(C. M. Hutchinson, C.I.E., B.A.)

I. Administration.

Mr. J. H. Walton, Assistant Bacteriologist, was in charge of the Section till 4th October, 1921, after which I held charge for the remaining period of the year under report.

Mr. R. C. T. Petty, B.A., who was appointed as Assistant Bacteriologist on 22nd November, 1921, died on 15th March, 1922.

Mr. N. V. Joshi, First Assistant, acted as Assistant Bacteriologist and Mr. K. S. Viswanatham as First Assistant till 4th October, 1921.

II. Training.

Mr. Fazal-ud-din, a private student, was under training up to 18th December after which he was taken up as laboratory assistant in this Section.

Babu Indu Bhusan Chatterji, Assistant to the Agricultural Chemist, Bengal, was under training in this Section during the year under report.

III. Soil Biology.

Nitrogen fixation. Work was done on symbiosis between algæ and nitrogen-fixing bacteria and on the value of plant residues as nutrients for nitrogen-fixing bacteria.

The abundant algal growth that took place in suitable media inoculated with soil and exposed to diffuse daylight was found to be accompanied by a much higher fixation of nitrogen than in duplicate sets of medium kept in the dark, where algal growth was not visible.

Fermented green manure was found to contain a readily available supply of foodstuff for the growth of Azotobacter. This is an important factor to be considered when compar-

ing the relative values of fermented and unfermented green manures.

Root nodule bacteria. Cross-inoculation of indigo plants with nodule bacilli isolated from pea, cow-pea, and *methi* (Fenugreek) was successfully carried out as was the inoculation of these three plants with the indigo nodule bacillus.

Manuring of indigo plants with nitrate retarded or entirely suppressed nodule formation.

Typical root nodule bacilli were isolated from the nodules of *Casuarina equisetifolia.*

Nitrification. *Mahua cake.* The increased nitrification of *mahua* (*Bassia latifolia*) cake due to previous composting of the cake with nodule phosphate alone or with the addition of sulphur, soil, or both sulphur and soil was again observed, and detailed experiments carried out.

Quantities of fresh *mahua* cake or the compost, sufficient to supply 30 mg. nitrogen per 100 grm. Pusa soil, were taken. With fresh cake, the original nitrate nitrogen of the soil disappeared after one week, and the amount of nitrate then gradually increased in eight weeks to about the original amount. After a further ten weeks, the nitrate amounted to the original quantity in the soil plus 18 per cent. of the added nitrogen.

When compost was added to the soil, nitrification proceeded slowly but steadily, and after eighteen weeks up to 40 per cent. of the added nitrogen was recovered as nitrate.

The addition of the other ingredients of the composts direct to the soil slightly retarded the rate of nitrification of the *mahua* cake.

Solubilization of rock phosphate. The series of experiments mentioned in the last annual report were continued and extended, and showed that varying amounts of the phosphate of Trichinopoly nodule phosphate were rendered citrate-soluble by various composts. The nodules contain 25 per cent. total phosphate and 16 per cent. calcium carbonate. The maximum amount soluble was found

after sixteen to twenty weeks, after which the amount of soluble phosphate decreased. The most effective compost tried consisted of the nodule phosphate, *mahua* cake, and sulphur (50 grm. cake, 25 grm. phosphate, $6\frac{1}{4}$ grm. sulphur), by which 4·32 per cent. of citrate-soluble phosphate (P_2O_5) was obtained from the nodule. A compost of cake and nodule alone gave 3·6 per cent. of soluble phosphate, and the addition of 50 grm. soil to the first compost lowered the percentage of citrate-soluble phosphate to 2·6. Substitution of green manure (sann-hemp) for cake produced less efficient composts, in which only two-thirds of the above quantities of phosphate were made soluble.

Cattle manure. The observations on the losses of nitrogen from cattle dung and urine when stored separately or in mixture showed that greater losses occurred when these were stored in mixtures than when stored separately. While the urine lost most of its nitrogen when stored under aerobic conditions, there was little loss after many months' storage under anaerobic conditions. A thin layer of oil on the surface of urine provided the necessary anaerobic conditions.

Biological analysis of soils. The biological analyses of several types of soil from Bengal were completed.

Soil samples received from the Deputy Director of Agriculture, Konkan Division, were examined. When these soils are burnt in the field, the following crop is better than on soil that has not been burnt.

The burnt soil was found to contain more nitrogen as ammonia than the fresh soil, and experiments on ammonification and nitrification of oil-cake showed that greater accumulation of ammonia, but less formation of nitrate, took place in the burnt than in the untreated soil. No effect was produced by inoculation of burnt with fresh soil. The burning in the field had been carried out five months before the samples were sent to Pusa, but samples burnt in the laboratory gave similar results to the samples burnt in the field.

These soils are generally burnt in the hot season, six to eight weeks before the monsoon. So the checking of nitrification would reduce losses of nitrogen by leaching from well-drained soil of hill slopes or by nitrate reduction in the heavy *mânat* soil near the coast.

As paddy is the crop grown in the *mânat* soil, it there finds a readily available supply of nitrogen as ammonia.

Experimental plots. On one block divided into sixteen plots, oats were grown, and wheat on a second block. Groups of four plots on each block were irrigated one, three, and five times respectively and a control group received no irrigation. Nitrate of soda was applied to all plots, at the rate of 240 lb. per acre. The yield of grain and straw of both crops increased as the number of irrigations increased. The increases in grain and straw of the five times irrigated plots over the controls were for wheat—grain 40 per cent., straw 75 per cent., and for oats—grain 83 per cent., straw 100 per cent.

In a second pair of blocks, on which wheat and oats were grown, and which were divided in the same manner as the first pair, one group of four plots received 240 lb. of nitrate of soda at the beginning of the experiment, the second group received one application of 120 lb. nitrate of soda at the start and a second one month later, the third group received three applications of 80 lb. nitrate of soda at intervals of three weeks. The fourth group was unmanured.

The division of the nitrate and application in separate doses had but slight influence on the crop yields.

A further series of small plots was laid down for the purpose of investigating the vertical distribution of nitrates in the soil, and the influence of cultivation, rainfall, and applications of nitrate upon nitrification. Among the conclusions to be derived from the observations were :

(*a*) Additions of nitrate up to the limit (240 lb. $NaNO_3$ per acre) used in the experiment increased the amount of nitrification in the soil.

(*b*) More nitrate is found in the first three feet of cultivated than of uncultivated fallow soil, but rain washes out more nitrate from the cultivated soil and leaves it poorer in nitrate than the uncultivated.

IV. Indigo.

The study of the classification and efficiency of indican hydrolysers was continued. A variety isolated from the water supply at Dholi factory allowed of the recovery of 85 per cent. of the indican of leaf extract as indigotin after hydrolysis and blowing. Mass cultures of this organism were used in the vat trials of the second cutting in September 1921 conducted by the Indigo Research Chemist.

Eight samples of water from different sources were reported on.

The bacterial flora of a sample of putrefying indigo paste was found to contain spore formers with a high thermal death point.

V. Water sterilization: "E.C."

The supply of "E.C." for use on the Pusa Estate and in hospitals in the Muzaffarpur and Darbhanga Districts was continued throughout the year. Arrangements were made to increase the outturn and supply other large hospitals in Bihar.

Investigations were carried on with various types of cell and electrode in order to select a suitable design of apparatus for manufacture for the use of hospitals, etc., where large quantities of E.C. could be used, and where it would be of advantage for the consumer to make his own supply.

VI. Programme of work for 1922-23.

Major.

I. Soil biology—

(*a*) *Nitrification.* Investigation of conditions affecting this process in Indian soils.

(*b*) *Nitrogen fixation.* Research on the natural increment of nitrogen in soils as a result of the activities of the so-called non-symbiotic soil organisms; the possible symbiotic function of soil algæ.

(*c*) The decomposition of organic residues and manures in Indian soils; green-manuring.

(*d*) Solubilization of mineral phosphates by bacterial action. Composting with indigenous phosphates and bonemeal.

(*e*) Training of students.

II. Industrial biology—

(*f*) Production of digestible food products by fermentation of relatively indigestible vegetable foods by methods suitable for utilization by the Indian cultivator; "Natto" from Indian legumes.

(*g*) Silage. Fermentation of—.

(*h*) Fibre. Retting of—.

Minor.

(*a*) Bacterial diseases of plants.

(*b*) Study of root nodules of certain leguminous and non-leguminous plants.

VII. Publications.

Hutchinson, C. M., and Hodgkinson, W. — Report on Electrolytic Chlorogen (E.C.). *Ind. Jour. Med. Res.*, Vol. IX, p. 586.

Walton, J. H. — Report on Agricultural Bacteriology, 1920-21, for the Board of Scientific Advice.

Joshi, N. V. — Studies in Methods to prevent Nitrogen Losses from Dung and Urine during Storage. *Agri. Jour. India*, XVII, p. 367.

REPORT OF THE IMPERIAL MYCOLOGIST.

(W. McRae, M.A., B.Sc., F.L.S.)

I. Charge and Establishment.

Dr. F. J. F. Shaw held charge of the Section till 29th December, 1921, when Mr. W. McRae returned from a year's combined leave and took over charge. While Mr. J. F. Dastur, Officiating Second Imperial Mycologist, was on privilege leave for one month and a half from 22nd August, 1921, Mr. M. Mitra, the First Assistant, officiated as Second Imperial Mycologist.

II. Training.

Mr. L. S. Bertus of the Ceylon Agricultural Department completed his period of one year's training on 29th July, 1921, and Mr. P. D. Nair, L.Ag., Assistant to the Government Mycologist, Central Provinces, on 31st May, 1922. Mr. T. N. Sen, B.A., joined as a post-graduate student on 25th July, 1921.

III. Diseases of Plants.

(1) **Cereals.** *Piricularia Oryzæ* Br. et Cav. that causes a leaf spot and a discoloration and collapse of the haulm resulting in empty or partially filled ears of *Oryza sativa* (paddy) has been recorded from Baluchistan, Punjab, Bihar, Bengal in Northern India and from both the east and west coasts and the central area of Madras. Only in 1918 in Madras it is definitely known to have been epidemic but its having caused a small but noticeable amount of damage has been the reason for its collection in the other places. The loss in grain during the epidemic was as high as 90 per cent. in fields of an acre and 76 per cent. over 1,700 acres observed. The appearance of the disease is erratic. In the year after the epidemic in Madras the fungus was not found in the previously infected area

though careful search was made for it during a period of two and a half months. Yet *P. repens*, that is, the common grass of the rice " bunds " and water channels, was attacked by a *Piricularia* in a severe epidemic form. In Madras and Bihar fifty per cent. of the seedlings in the seed-bed may be infected slightly and after being transplanted the plants may ultimately become almost free from disease. Infection experiments and the available meteorological records indicate that highly moisture-charged air and a definite temperature are the limiting factors most concerned in deciding whether the disease is to be absent or cause slight or great loss. Species of *Piricularia* similar to that on the rice plant have been found on *Eleusine coracana*, *Panicum repens*, *Setaria italica*, *Paspalum sanguinale*, *Triticum vulgare* and *Panicum ramosum*. On the first two only has the fungus been found in epidemic form. The loss in grain in *Eleusine coracana* has amounted to 50 per cent., while *P. repens* is a wild grass of no economic value. Cross-infection experiments indicate that the *Piriculariaes* on *Oryza*, *P. repens* and *Paspalum*, though each infecting its own host, will not infect the others and that those on *Eleusine*, *Setaria* and *Triticum* are interchangeable among themselves though they will not infect the three previously mentioned hosts. The *Piricularia* on *P. ramosum* has been but recently found and nothing is known of its behaviour. The question whether there are four physiological strains of one fungus or four different species is left undecided as yet. Their anatomical and cultural characters are not very distinct but their ability to infect different hosts under our conditions is definitely restricted. Similar indications are observed in the field. While rice plants were infected with epidemic violence, plants of *P. repens* remained free and *vice versâ*. *Eleusine* and *Setaria* growing in the same field were both infected as also *Eleusine* and *Triticum*. Of *Eleusine*, *Setaria* and *Paspalum* in the same field, only the last was infected.

Two other diseases of paddy have been under investigation. One of them is caused by a sclerotial fungus which

has not at present been identified. The sclerotia of this fungus are irregular brownish structures of considerable size (1-4 mm.) and this parasite is thus easily distinguished from the relatively commoner *Sclerotium Oryzæ* Catt. It resembles in some respects the species *S. irregulare* Miy., which is known as the cause of damage in rice fields in Japan, and also the species *S. glumale* Ces., which has been recorded in Borneo. In India the parasite produces spots on the leaf sheath. These spots are very characteristic consisting of a light yellow brown area sharply demarcated by a dark reddish brown line. Under favourable conditions the fungus spreads over the whole plant which is speedily killed. The symptoms of the disease and the morphology of the parasite closely resemble those of a disease of sugarcane, which has been described in Java, under the name Djamoer Oepas, and has since been collected in India. Work is in progress to determine whether the causal fungus of the disease on paddy is identical with that on sugarcane.

The second disease of paddy is possibly caused by a species of *Cephalosporium*. The symptoms of disease in this case are a failure of the plant to produce grain. Paddy showing these symptoms, and infected with this fungus, has been obtained from Burma and Assam and cases are recorded from the Central Provinces. It is as yet by no means certain whether the fungus which has been obtained in culture is the cause of the disease. It is not improbable that soil conditions may be the predominant factor in determining the incidence of this fungus as a parasite.

The smut (*Tolyposporium Penicillariæ* Bref.) on *bajra* (*Pennisetum typhoideum*) was investigated, at the request of the Director of Agriculture, Baroda State. This millet is one of the most important agricultural crops of the State and considerable annual loss in yield is caused by the smut. Preliminary experiments have shown that this disease is amenable to treatment. Plants from seeds treated with hot water at 60°C. for 10 minutes and with hot formalin vapour at 98°C. for 20 seconds gave a considerably less

number of smutted heads than plants from untreated seeds. Ordinarily the percentage of smutted heads is between 30 and 40 but the percentage was reduced to 8 and 15 in the case of the plants raised from seeds treated with hot water and hot formalin vapour respectively. The seed treatment reduces a little the percentage of germination. Spraying flower-heads with Burgundy mixture and lime-sulphur and bagging the inflorescence from the time it was in the enveloping spathe to the time the seeds were set, had no effect in controlling the smut. The presence of the smut mycelium has been traced in seeds which look apparently normal; this confirms the field observations which had suggested that the disease was being carried in the seed. In seeds, not much infected, the mycelium is found in the scutellum and in the seed-coat near the embryo.

Experiments on a field scale are being tried in the present season for controlling the smut by treating the seeds with hot water and with formalin and copper sulphate solutions. Hot formalin vapour treatment is not practicable for treating seeds on a field scale under our conditions, and so it is not continued this season. Seeds from Mirpurkhas and Lyallpur, where this smut does not occur, are being tried at Baroda and Pusa.

The control of the downy mildew of maize by seed treatment is under investigation. The relationship between the downy mildew on a grass (*Andropogon* sp.), common in Pusa during the rains, and on maize is being studied.

Other seed-borne diseases of *bajra* and maize such as *Fusarium*, *Diplodia* and *Acrothecium* are also under study.

The study of the genus *Helminthosporium*, species of which are parasitic on cereals, was continued by Mr. M. Mitra. Cross-inoculations with *Helminthosporium* on rice, barley, wheat and sugarcane were repeated and last year's results were confirmed that these four species are closely allied and that they readily infect each other's hosts. *Helminthosporium* on wild grasses are being studied to see whether the species on the cereals also occur on wild grasses and whether the wild grasses serve as intermediate hosts for

these fungi to pass the period between two crops. The species of *Helminthosporium* on smaller millets such as *Setaria italica*, *Panicum frumentaceum* and *Eleusine coracana* were also studied. The effect of the formalin and the hot water treatments against *Helminthosporium* was tried on barley and oats at the time of sowing. The disease was less on barley under both treatments though the latter treatment reduced the germination of the seed to a small extent. The differences on the various plots were too small to be conclusive.

Urocystis coralloides Rostrup on mustard appeared again on the same field. The infected plants show less branching and remain small if the infection takes place early. The fungus forms galls up to 1½ inches in diameter on roots and rootlets. It fills the cavities of cells with its mycelium and later on the whole mycelium is replaced by a mass of spore-balls. Unfortunately spores did not germinate under any of the conditions tried, so the life-history still remains obscure.

(2) **Sugarcane.** A suspected outbreak of Mosaic disease of sugarcane in Sind was investigated and proved to be unfounded. Suspicious symptoms in two varieties—American D99 and Sathi—at Pusa were also studied. Hypodermic injections from Sathi canes, which were suspected of Mosaic, into healthy Sathi canes caused a discoloration of the leaves similar to that found in the leaves of suspected plants. Neither the " diseased " nor the infected plants were the worse for this discoloration.

The thick varieties of sugarcane are generally reported to be smut-resistant, while the thin varieties are susceptible to the smut. While investigating the cause of this reported immunity of thick canes to smut, it has been observed that they are not necessarily smut-resistant. The resistance of the following thick varieties—American D99, Sepaya, Malabar, Badela and Sathi—was studied and it has been found that they are susceptible to artificial infection; though in nature they are as a rule free from smut.

(3) **Jute.** Experiments to determine the influence of applications of sodium sulphate, as manure, on the growth of jute and the incidence of disease in the crop were continued throughout the year. The study of *Macrophoma Corchori* Saw. was continued both at Pusa and at Dacca. The fungus causes a stem rot of jute, similar to that already described as due to the attack of *Diplodia Corchori* Syd. The disease is most severe when there is a deficiency of potash in the soil. Applications of sodium sulphate appear to have had a considerable influence in reducing the incidence of this parasite. The spore stage of this fungus occurs only on the jute plant, and in artificial culture the fungus remains sterile, producing a small black sclerotia. This sclerotial form of the fungus appears to be identical with that previously described in India as *Rhizoctonia Solani* Kühn.

The demonstration of methods of spraying in orchards against fungul diseases of the apple, pear, peach, etc., were continued. A type of sprayer, new to India, has been introduced and given an extensive trial during the present season on a commercial orchard. The results indicate that a considerable saving in time, labour and material can be effected with the new type of machine. A study of the method of preparing lime-sulphur with lead arsenate is being carried out in collaboration with the Imperial Agricultural Chemist.

IV. Systematic work.

Five hundred and seventeen specimens were added to the herbarium during the year, many of them being presented by the courtesy of several outside workers. A fungus and host index of the mycological herbarium at Pusa was completed.

V. Water Hyacinth.

The problem of destroying water hyacinth has been referred by the Government of Bengal to a special commission whose report is not yet issued.

VI. Programme of work for 1922-23.

(1) *Research work.* New diseases of Indian crops that come to the notice of the Section will be investigated. The following crops and diseases will receive special attention:—

(*a*) Diseases of jute.
(*b*) Foot rot of cereals.
(*c*) Stripe disease of cereals.
(*d*) Diseases of cereals and grasses caused by species of *Piricularia*.
(*e*) Orchard diseases.
(*f*) Sugarcane diseases.

(2) *Systematic work.* This will be carried out in conjunction with the Imperial Bureau of Mycology in London.

(3) *Training.* Students and assistants will receive training on the lines indicated in the prospectus.

(4) *Routine work.* Advice and assistance as required will be given to other departments and the general public.

VII. Publications.

Shaw, F. J. F. . . Report on Mycology, 1920-21, for the Board of Scientific Advice.

,, ,, . . A Diseased Condition of Rice. *Agri. Jour. India*, XVII, Pt. 2, March 1922.

Dastur, J. F. . . Cytology of *Tilletia Tritici* (Bjerk.) Wint. *Ann. Bot.*, XXXV, No. CXXXIX, July 1921.

,, ,, . . Die-back of Chillies (*Capsicum* spp.) in Bihar. *Mem. Dept. of Agri. in India, Bot. Ser.*, Vol. XI, No. 5, September 1921.

Mitra, M. . . . *Helminthosporium* on Cereals and Sugarcane, Pt. I (*Helminthosporium* Diseases of Maize and *Jowar*). *Mem. Dept. of Agri. in India, Bot. Ser.*, Vol. XI, No. 10. (*In the press.*)

Subramaniam, L. S. . The genus *Cerebella* in India. *Jour. and Proc. Asiat. Soc. Bengal*, N S., Vol. XVII, No. 2, December 1921.

List of Specimens in the Mycological Herbarium at Pusa.

REPORT OF THE IMPERIAL ENTOMOLOGIST.

(T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S.)

I. Administration.

The Imperial Entomologist held charge of the Section throughout the year ended 30th June 1922 and, in addition to his own duties, was also in charge of the work in pathological entomology. Mr. P. V. Isaac was appointed as Second Entomologist (Dipterist) with effect from 16th June 1922 and commenced duty at Pusa from 26th June. The post of Supernumerary Entomologist remained vacant throughout the year. Mr. G. R. Dutt, Personal Assistant, in addition to his own duties, officiated as First Assistant from the beginning of the year to 1st September 1921, during the absence of Mr. C. S. Misra on furlough. Mr. P. G. Patel, Assistant, was on deputation in the Punjab throughout the year, working under the Camel Specialist, Sohawa.

II. Training.

Sardar Niranjan Singh, B.Sc., was deputed from the Khalsa College, Amritsar, for training in Entomology for one year; he joined the course on 1st June 1921 and completed it on 31st March 1922. Mr. Hem Singh Pruthi, of the Punjab Entomological Staff, worked in the laboratory for a short time. Two students were trained in sericulture.

III. Insect Pests.

Work on Borers in sugarcane and other gramineous plants was continued on the lines indicated in previous Reports but, except in details which are not suitable for a Report of this nature, few noteworthy facts require reference. Three species of Borers have been found in *Imperata arundinacea* but are still in the larval stage. The counting of dead and dry-heart canes was not successful as sufficient data could not be obtained for comparative purposes

owing to the necessity for removal of the experimental plants on account of an outbreak of mosaic leaf disease. Sugarcane affected by borers was sent from Kopargaon and the borers, which were few in number, were found parasitized by a Tachinid fly.

Diacrisia obliqua (Arctiadæ) was especially bad at Pusa after an interval of ten years, during which of course it has occurred regularly as a minor, but not a major, pest. It attacked soybeans, sann-hemp, jute, cow-peas, *urid* (*Phaseolus radiatus*), *moth* (*P. aconitifolius*), castor and *Dolichos lablab*, and was checked by hand-picking of the egg-masses and of the young larvæ whilst still gregarious.

Monophlebus octocaudatus (Coccidæ), which suddenly became quite scarce at Pusa about four years ago, is again gradually increasing in number and gave some trouble by attacking mango and peach trees. Eggs collected in June 1921 hatched on 24th November under laboratory conditions and at about the same time under natural conditions.

Termites (*Microtermes obesi*, Holmgr.) attacking growing sugarcane were checked by the application of crude oil emulsion to the irrigation water.

In the wheat experimental plots suffering from the attack of an Aphidid (? *Macrosiphum granarium*), the effect of collecting and liberating Coccinellid beetles was tried with good effects; this will be tried again on a future occasion. It is probable that the local custom of growing wheat intermixed with mustard is beneficial in this way, as the Coccinellids bred on the mustard Aphidids later on attack the Aphidids on the wheat.

The effect of attack of an Aphidid on peach trees at Pusa was rather striking. The trees were quite healthy and the fruit within about three weeks of ripening when the leaves and shoots were badly attacked, with the result that the fruit wholly failed to ripen, some dropping off the tree and some remaining on the tree for about six weeks after its normal date, when it rotted, still unripe, in the rain.

A cigarette factory reported extensive damage due to the Cheroot Beetle (*Lasioderma serricorne*). This factory works on a large scale, with a normal daily out-turn of about two million cigarettes, and the loss last year, due to destruction of finished product and loss on contracts and working, was estimated at about seven *lakhs*. The factory was inspected and fumigation of the finished cigarettes with hydrocyanic acid gas was recommended. Experiments having shown that the flavour of the cigarettes would not be affected, a fumigation chamber was set up and its working demonstrated; it is believed that the trouble has been checked, as no further complaints have been received.

Work on the relative immunity of varieties of cotton was continued on the line of previous years. The distribution of *Earias fabia*, *E. insulana* and *Platyedra gossypiella* was studied. The role of *Oxycarenus lætus* and its life-history were worked out.

Owing to the very extensive importation of American cotton at present, much of it coming direct to Bombay from American ports, there seems to be considerable danger at present of the importation into India of the Boll Weevil (*Anthonomus grandis*). Besides American cotton, a good deal is also being imported from Uganda. Examination has shown that some bales contain broken cotton stalks, leaves, and whole seeds. The situation is being watched carefully.

The following are some of the more interesting insects sent in by correspondents during the year :—

(1) A large Pentatomid bug, apparently *Rhynchocoris humeralis*, damaging oranges at Tippera.

(2) Pear fruits infested with Trypaneid larvæ, from Maymyo.

(3) Geometrid larvæ damaging roses at Kurseong.

(4) Weevils (*Tanymecus sciurus*, Oliv., *Myllocerus discolor*, and an unidentified species) from the Government Entomologist, Lyallpur.

(5) *Anomis involuta*, Wlk (*Cosmophila sabulifera*)* (Noctuidæ) attacking fibre leaves at Gorakhpur.

(6) *Amsacta moorei* (Arctiadæ) attacking maize, *juar* (*A. Sorghum*), *urid*, *mung* (*P. mungo radiatus*), *moth* and indigo at Gorakhpur.

(7) Borers in sugarcane from various localities.

(8) *Astycus lateralis* (Curculionidæ) damaging garden plants at Muzaffarpur.

(9) *Hieroglyphus banian* (Acrididæ) damaging rice crop in Champaran.

(9a) *Rhynchochoris humeralis*, *Cappæa taprobanensis*? on orange, and *Monohammus versteegi* and *Rhytidodera simulans* ? on mango from the Entomological Assistant, Bengal.

(10) *Chætodacus cucurbitæ* (Trypaneidæ) damaging cucurbits at Karachi.

(11) *Dialeurodes citri* (Aleyrodidæ) attacking *Citrus* leaves, from Government Entomologist, Lyallpur.

(12) Saffron corms from Director of Agriculture, Kashmir, said to be affected by some insect, but nothing emerged.

(13) Cocoons of a Braconid parasite found on *nim* (*Melia azadirachta*) leaves at Pratabgarh. These were locally credited with being a supernatural growth of cotton.

(14) Croton leaves badly infested with Coccidæ, from Calcutta.

(15) *Rhynchophorus ferrugineus schach* (Curculionidæ) from Port Blair.

(16) *Ripersia* sp. (Coccidæ) infesting Rhodes grass roots on the grass farm at Bangalore.

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* This insect is *Cosmophila sabulifera* of the *Fauna* volume and of Indian entomological literature generally but is not *sabulifera*, Guen., a species which occurs in Abyssinia and East Africa. The Plate issued in last year's Report should be corrected accordingly.

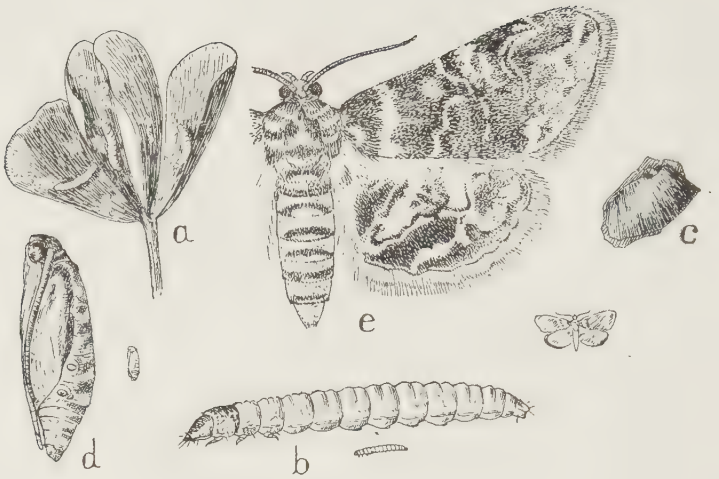


Fig. 1. *Nymphula turbata*, Butl.

a, Larvæ feeding on leaves of *Marsilea quadrifoliata* (× 2); *b*, Larva (× 7); *c*, Leaf-case (× 1); *d*, Pupa (× 7); *e*, Moth (× 7). Smaller figures show natural sizes.

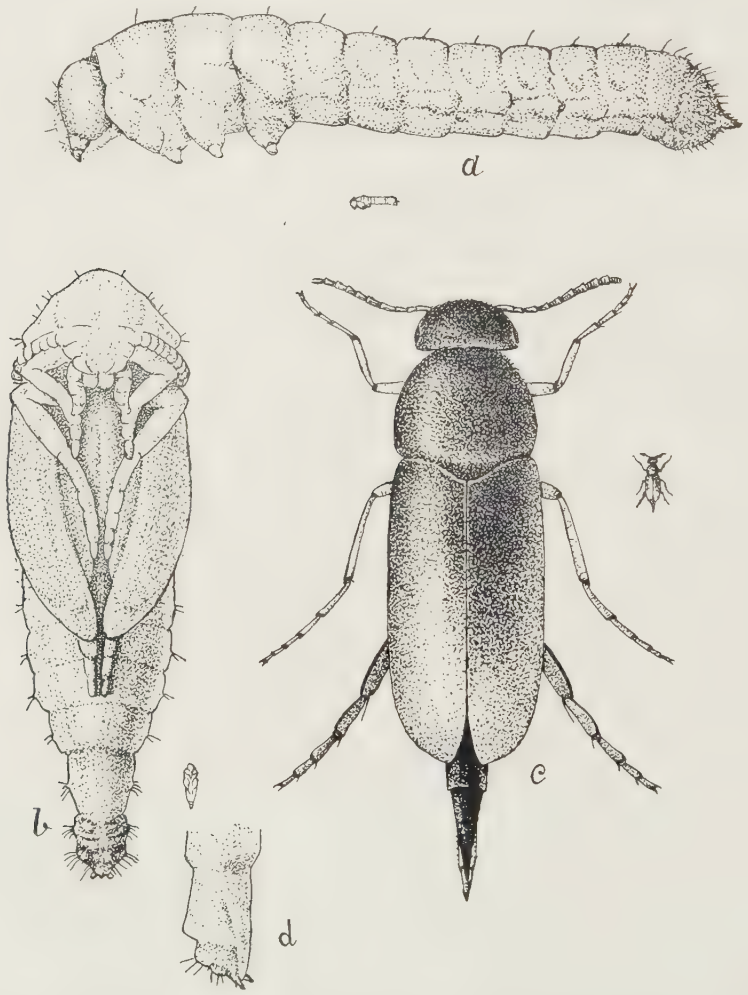


Fig. 2. Mordellid Beetle found boring in stems of *Lippia nodifolia*.

a, Larva (× 20); *b*, Pupa (× 20); *c*, Imago (× 20); *d*, Lateral view of terminal segment of pupa. Smaller figures show natural sizes.

(17) Larva and pupa of a longicorn beetle, probably a species of *Batocera*, found boring in wood at the Nundydroog Mine, Oorgaum.

(18) *Platyptilia* sp. (probably *pusillidactyla*, Wlk., but in bad condition) found breeding on *Utricularia* sp., from Quilon.

(19) An Aphidid and a Flea-beetle (*Chætocnema basalis*) attacking *juar* at Hissar.

(20) *Phyllotreta* sp. (Chrysomelidæ) attacking vegetable plots at Muktesar.

(21) Larvæ of *Parasa* sp. (probably *P. lepida*) (Heterogeneidæ) destroying coconut leaves in the Andamans.

(22) *Bagrada picta* (Pentatomidæ) infesting cabbages, cauliflowers and turnips on the Military Grass Farm, Meerut.

(23) *Psara bipunctalis* (Pyralidæ) on brinjal leaves and *Nephopteryx* sp. (Pyralidæ) on *Cassia nodosa*, from Sabour.

(24) *Crocidosema plebeiana*, Zell. (Eucosmidæ), reared on hollyhock, from the Government Entomologist, Punjab. This is an European species, already recorded from Ceylon, but not definitely noted in India before.

(25) *Ætherastis circulata*, Meyr. (Hyponomeutidæ), from Mooply Valley, Pirmad and Tenmalai, attacking bark of Para rubber trees.

Life-histories. Besides the insects noted above, a large number of different insects has been reared during the year, their life-histories described and drawn, and their habits and foodplants noted. Many of these are as yet unidentified and are probably new to science, so that it is only possible to mention a few by name.

Nymphula turbata, Butl. (Pyralidæ) was reared from larvæ feeding on leaves of *Marsilea quadrifoliata*. (Plate II, fig. 1.)

Perigea capensis (Noctuidæ) was found feeding on leaves of *Eupatorium fœniculaceum*.

Terias silhetana (Pieridæ) was reared on *Cæsalpinia bonducella* leaves.

Cosmopteryx bambusæ, Meyr. (Cosmopterygidæ) was reared from larvæ mining leaves of *Saccharum fuscum*.

Eretmocera impactella, Wlk. (Heliodinidæ) was reared on leaves of *Alternanthera sessilis*.

Dichocrocis punctiferalis (Pyralidæ) was reared from larvæ boring pods of *Cæsalpinia bonducella*.

Suastus gremius (Hesperiadæ) was reared from larvæ on leaves of date palm (*Phœnix sylvestris*).

Silvanus surinamensis (Cucujidæ) was found infesting stored walnuts, which were badly damaged.

Agromyzid fly larvæ were reared from leaves of rice, linseed, pea, cauliflower, and a Composite plant, but the identification of these flies is not possible at present.

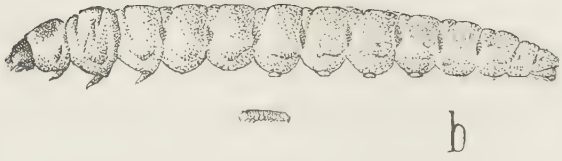
Larvæ of the longicorn beetle, *Stromatium barbatum*, boring in dead wood under dry conditions are still living after five years in the larval stage.

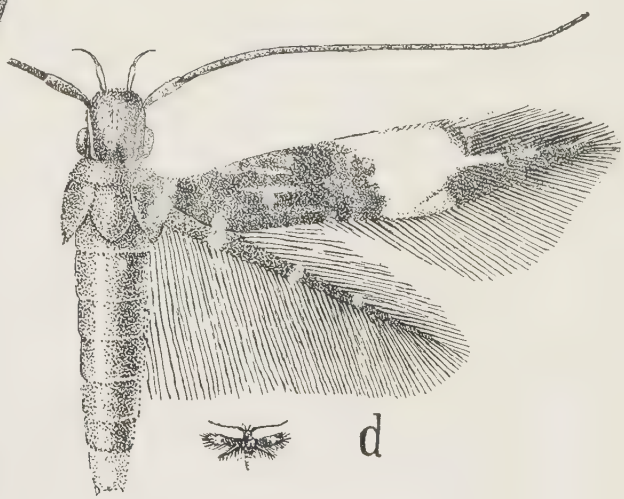
The full life-history of *Danais limniace* has been worked out. Its eggs are found to be parasitized by a small Chalcidid which has also been studied.

A small Mordellid beetle was reared from larvæ found boring in the stems of *Lippia nodifolia*. It has not yet been identified but, as little is on record concerning the early stages of this family in India, illustrations of the larva, pupa, and beetle are now given (Plate II, fig. 2).

In August 1921 some larvæ, probably of an Asilid fly, were obtained under earth but could not be induced to pupate, although they remained active for about three months in moist earth containing earthworms, which they were never actively seen to attack. The larvæ were eucephalous and typically amphipneustic, with stout jaws, which seemed to be well adapted for tearing off food-material, and characteristic posterior spiracles (Plate III, fig. 1).

Cosmopteryx mimetis, Meyr. (Cosmopterygidæ) was again bred from larvæ mining leaves of *Cyperus rotundus*



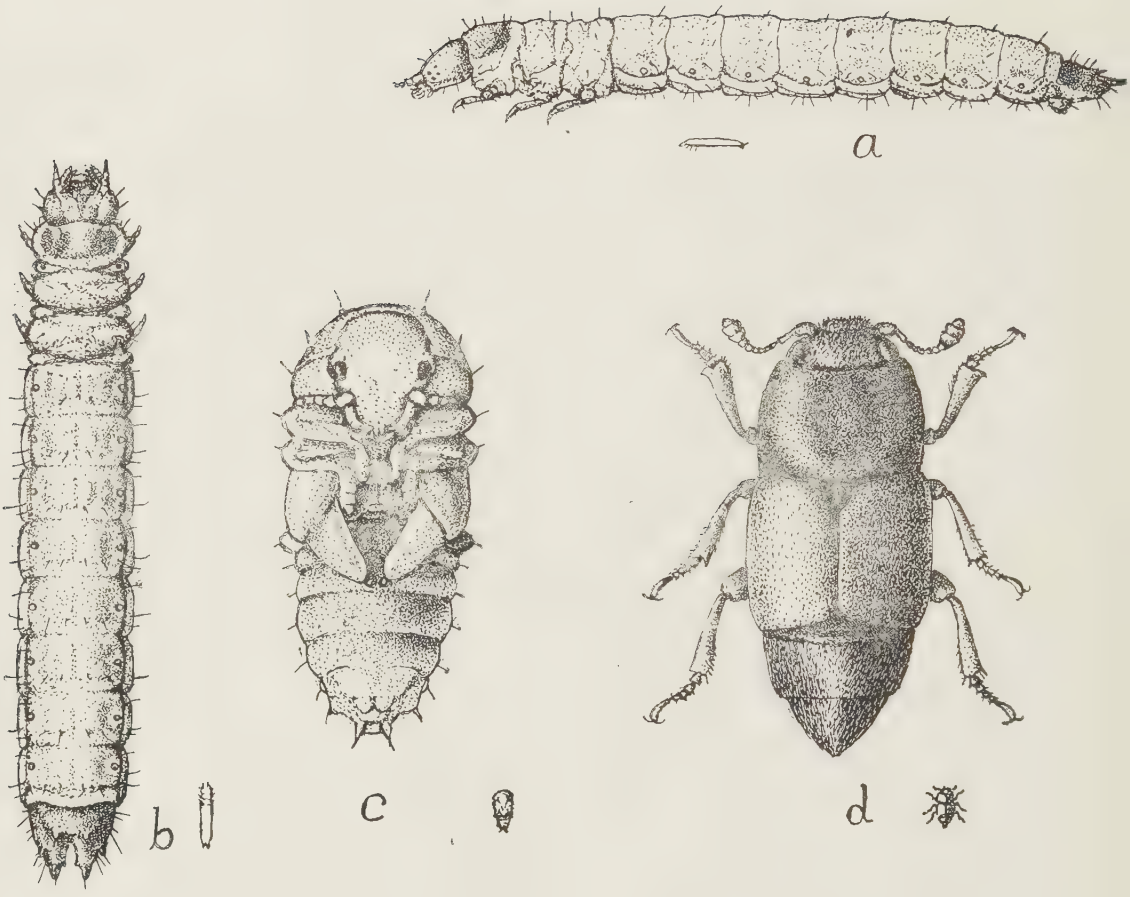


g. 1. An Asilid larva (×4).

Posterior spiracle (× 34).

Fig. 2. *Cosmopteryx mimetis.*

a, Mined leaf of *Cyperus rotundus*, tip dried up; *b*, Larva (× 16); *c*, Pup (× 16); *d*, Moth (× 16). Smaller figures show natural sizes.



Carpophilus nitidulus.

a, Larva, lateral view (× 16); *b*, Larva, dorsal view (× 16); *c*, Pupa (× 16); *d*, Imago (× 16). Smaller figures show natural sizes.

and the opportunity taken to figure the early stages (Plate III, fig. 2). This little moth is very widely distributed in the tropics but its life-history remained unknown until it was reared at Pusa from *Cyperus*.

Carpophilus nitidulus (Nitidulidæ) (Plate IV) was reared from larvæ found living in dried figs and dates purchased in Calcutta. It is a common household pest, attacking dried fruits.

Pathological Entomology. Work under this heading (apart from the systematic side, dealt with under Insect Survey) has been continued mainly with reference to Culicidæ, *Ochromyia*, Mallophaga and Anoplura.

A species of *Ochromyia* (*O. jejuna ?*) is common in the adult stage at Pusa from about June to August but has hitherto eluded all attempts to unravel its life-history, which is expected to prove of some interest in view of the close relationship of this Muscid fly to others whose early stages are known. A very large number of attempts has been made to discover its young stages and to make these flies oviposit in captivity, but without success. Amongst the various situations which have been searched for larvæ or empty puparia, may be mentioned the following :—termites' nests, soil inhabited by earthworms, toads and crickets, wet patches of soil in the vicinity of temporary collections of water, indigo "seet," tree-holes, cow-dung, stable refuse, bamboo groves (especially the earth covering the roots, as *Ochromyia* adults have occasionally been found to frequent such places), crevices in walls, floors, etc., in cow-sheds, floor of a *kachcha* sheep-shed, loose earth near roots of large trees, under stored fuel and bricks, floors of mud houses in villages, rotten wood and moss, birds' nests, in egg-masses of frogs and toads, near roadside drains, in putrefying vegetation and disintegrating animal matter, etc. During May and June some toads and frogs and specimens of *Brachytrypes* and *Schizodactylus* were dissected out and examined for the presence of the larvæ of *Ochromyia* as possible internal parasites. In view of the occurrence of *Pollenia rudis* as a parasite of earth-

worms, a fact first discovered by Keilin in France and subsequently also in America, and the fact that the adult flies of *Ochromyia* are about at the time of year that earthworms come freely to the surface and that the flies often frequent bare patches of ground, such as flower-beds, where the worms are freely exposed, it seems quite possible that the larvæ may feed on earthworms; but at present that remains a mere conjecture, as so far we have been unable to discover even a hint of the actual food of the larval *Ochromyia*. Specimens of the flies have been dissected out at various times and their ovaries examined. In August 1921 the ova were found to be in an undeveloped condition but in June 1922, in two instances at least, the ova appeared to be ripe. The two sexes are quite alike in outward appearance and the extent of contiguity of the eyes furnishes no indication of the sex, the eyes of the male never being holoptic.

The problem of the role of blood in ovulation in Culicidæ was again attacked but without success. One line which is being approached is to ascertain whether a comparative study of the morphology of the mouthparts and internal anatomy of both male and female of *Stegomyia albopicta* may furnish any indication, a few examples of other insects in which both sexes are blood-suckers being also included in this study. It has been shown by Stephens and Christophers that, but for their attachment to the fat-bodies by means of the anterior filaments of the ovarian follicles, the ovaries are unconnected with any other process or organ, except of course for their prolongation into the oviduct. Direct access to the ova of any constituent of blood is therefore improbable. The exceptional nature of the three œsophageal diverticula, which are very unlike those of other insects, and the fact of the invariable presence in them of carbon dioxide and of a fungus, seems to indicate the necessity of a more intensive study of these organs in relation to the problem of ovulation, especially in view of the fact that their function still remains obscure in spite of the researches of various workers.

A good deal of work has been done on the investigation of Culicidæ and other insects breeding in tree-holes at Pusa, and in December-January Mr. H. N. Sharma toured to Mergui to collect Culicidæ from that district.

Attempts were made to devise methods of rearing a species of *Trichodectes* (*T. climax?*) found on the goat. Dwight-Pierce kept them enclosed in cups strapped onto the animal's body; in this method, if the cups are not very securely tied or if adequate precautions are not taken to prevent their displacement during the animal's movements (neither of which conditions is easy to ensure) the insects are likely to escape as, unlike *Hæmatopinus* spp., these lice are very active. Some results of a not very satisfactory nature were obtained by placing the lice in a glass-bottomed pill-box, the lid of which was replaced by a piece of very fine-meshed muslin securely tied over the box, which was strapped onto the animal's body with the muslin in contact with the skin. Eggs were laid on the fibres of the muslin, whilst food could be taken through the meshes, close contact with the animal's body ensuring requisite warmth, whilst the glass permitted watching the insects' movements. But in many instances the eggs failed to hatch and in no case (although exhaustive trials were not given to this method) were the eggs reared right through to the adult condition. Two other methods tried and found unsuccessful were (1) on the lines suggested by Patton and Cragg, *i.e.*, placing the lice on the animal's ears and enclosing them in a muslin bag, (2) Warburton's method of rearing *Pediculus humanus* by placing the insects in tubes carried close to the person day and night.

Several cases of human myiasis due to *Chrysomyia bezziana* were brought to the Pusa hospital during the year and notes on these cases, prepared by the Medical Officer, were sent to Major Patton. In one case, in December 1921, an attempt was made to rear out a lot of very young maggots extracted from dead bone in the wound of a patient in the Hospital, but the attempt was unsuccessful in spite of every care, as the maggots refused to feed on raw-meat. This

would seem to confirm Patton's observation that the larvæ of *Chrysomyia bezziana* require living tissue to feed upon. On 26th February 1922, seventeen larvæ were received from the Pusa Hospital, having been extracted from the nose of a man suffering from syphilitic caries of the nasal bone; these larvæ were full-grown and all pupated by 28th February and emerged by 8th March as *C. bezziana*. Judging by the number of cases which occur in the small area served by the Pusa Hospital, *C. bezziana* must be a not unimportant cause of human myiasis (and resultant death in many cases, where not treated) in North Bihar.

Mr. S. K. Sen, Assistant, visited Muktesar in April and gave a short course of six discourses on some of the salient points in Entomology with especial reference to insects of pathological interest.

General collection of insects of pathological interest, with notes on their habits, life-histories, etc., was also made throughout the year.

IV. Bees, Lac and Silk.

Bees. No special work has been done with bees. The services of a whole-time Apicultural Expert are required if work is to be taken up seriously. In the meantime we can only deal in a small way with inquiries regarding Apiculture and supply improved hives, foundation comb, etc.

Lac. The emergence of lac larvæ took place at Pusa on 17th October 1921 and 30th June 1922. Owing to the great rise in the price of shellac, numerous inquiries were made by correspondents regarding the supply of brood-lac and as much *ber* (*Zizyphus jujuba*) brood-lac as could be spared was sent out from Pusa but no supply of *palas* (*Butea frondosa*) or *kusumb* (*Schleichera trijuga*) brood-lac could be arranged. The Bulletin on Lac-culture, which has been out of print for some time, has been re-written by Mr. C. S. Misra and submitted for publication; this Bulletin will be practically a new publication and not a mere reprint of the second edition. Mr. Misra visited the

Bankura District to report on the possibilities of rejuvenating the local lac-cultivation and to suggest measures for improvements in cultivation and manufacture.

The whole of our large collection of lac insects, from various parts of India and on various foodplants, has been sorted out and brought into order, and a microscopical study of the specimens has been begun with a view to discrimination of the species concerned.

A note on the determination of the date of emergence of lac larvæ, by Mr. Misra, was issued in the Report of the Fourth Entomological Meeting.

Silk. The sericultural establishment, which has been on a temporary footing, was closed down from 1st April 1922, when the Sericultural Assistant was transferred as Superintendent of Sericulture in the Department of Industries under the Bihar and Orissa Government. All the necessary apparatus for sericultural work and a number of finished silk pieces were also transferred at the same time.

During the period to 31st March, mulberry and eri silkworm eggs, castor and mulberry seeds and mulberry cuttings were distributed to various applicants. Silk exhibits were sent to several exhibitions. Silk pieces and yarns to the value of Rs. 3,753-6-6 were sold during the year and the proceeds credited to Government.

V. Illustrations.

Coloured plates illustrating the life-histories of *Metanastria hyrtaca and Danais limniace* were prepared during the year, as also a large number of black-and-white figures of insects under rearing and of crop-pests.

VI. Insect Survey.

The usual steady progress has been made in additions to, and arrangement and identification of, the collection of insect specimens, which, as it expands, becomes constantly more valuable for present and future work. No exact

census has been taken, but the collection is estimated to contain between seven and eight thousand named species, represented by about a million specimens. This forms, with our records, a key to the whole of our information regarding Indian insects and is increasingly taken advantage of by the Provincial Staffs and other workers on Indian Entomology for the identification of their material.

The Hymenoptera are in good order and well named up except for the Chalcidoidea and Braconidæ. The Mutillidæ, Scoliadæ, Pompilidæ, Sphegidæ, Eumenidæ, Vespidæ, Apidæ, Formicidæ and Ichneumonidæ have now been arranged in cabinets, of which about half-a-dozen more will be required to take the remainder of the collection still contained in store-boxes, which have proved very unsatisfactory for the proper preservation of specimens in a climate such as that of Pusa. A collection of Chalcidoids found in fruits of *Ficus glomerata*, *F. religiosa*, *F. bengalensis* and *F. infectoria* was sent to Mr. P. H. Timberlake, Honolulu, who is working these insects out and who reports that, from the fruits of *F. bengalensis* alone, nearly twenty-five different species have been separated.

The whole of the collection of Coleoptera is still contained in store-boxes. During the year all the unnamed Carabidæ were sent to Mr. H. E. Andrewes, who has returned them after identification. The whole of the Hydrophilidæ have been named up by Monsieur d'Orchymont, who has prepared a report on the collection, which is now in the press. The Silphidæ and Erotylidæ have been sent to Mr. Arrow. The unnamed Staphylinidæ and the major portion of the Nitidulidæ have been sent to Dr. M. Cameron.

The Lepidoptera collection, contained in store-boxes, is in fair order, but many accessions remain to be named up. The collection of Microlepidoptera is contained in cabinets; more than one thousand specimens were sent to Mr. Meyrick and identified by him, the collections sent containing many novelties which will be described in "Exotic Microlepidoptera."

The Orthoptera collection contains a mass of material which requires a great deal of sorting. Some progress has been made during the year. The Acrydidæ have been rearranged and several hundreds of specimens of Acrididæ have been sent to and received back named by Dr. Uvarov. The Dermaptera have been worked over by Mr. Morgan Hebard, whose report on the collection, including the description of ten new species, is now in the press. A few more Mantidæ, Blattidæ and Dermaptera have been sent to Mr. Hebard for identification.

The Neuroptera (*sensu antiquo*) are now either largely named up or in process of being so. The collection of Odonata is a large and important one, comprising about 237 out of about 407 known Indian species, and many novelties have recently been described by Major F. C. Fraser. The Sialidæ, Raphiadæ, Bittacidæ, Panorpidæ, Mantispidæ, Ascalaphidæ, Myrmeleonidæ, Nemoptera, Hemerobiidæ, Osmylidæ and Chrysopidæ have been sent to Mr. Esben-Petersen, who is now working them out. The Perlidæ and Trichoptera still require to be done.

A good deal of work has been done in sorting out and arranging the collection of Diptera, and about three-fourths of the material has at least been sorted into families. Several thousand specimens of Muscidæ have been sent to Major Patton for identification and the series of *Ochromyia*, Sarcophagidæ and Rhiniane Muscids to Mr. R. Senior-White. Arrangements have been made for the identification of the large collection of Tachinidæ and these will be sent out shortly. The specimens of stemboring Anthomyiadæ have been sent to Coimbatore where Rao Sahib Ramachandra Rao has undertaken their examination. The Stratiomyiadæ, Xylophagidæ, Cœnomyiadæ, Rhagionidæ, Nemestrinidæ, Cyrtidæ, Bombylidæ, Therevidæ, Scenopinidæ, Empididæ, Lonchopteridæ, Platypezidæ, Syrphidæ, and a portion of the Tabanidæ have been got together and arranged in cabinets. A large collection of European Diptera, purchased many years since, has also been removed from the open boxes in which

it was contained and properly labelled and placed in a cabinet; this will be very valuable for studying the systematics of Indian material much of which is founded on European types.

The collection of Rhynchota is wholly contained in store-boxes and requires thorough revision and rearrangement.

Numerous collections of Indian Insects have been received during the year and named as far as possible. These included collections by the Forest Research Institute, the Zoological Survey, the Provincial Departments of Agriculture, the Bombay Natural History Society, and by numerous correspondents.

VII. Catalogue of Indian Insects.

The first part of the Catalogue, on Acrydidæ, was published during the year and the second and third parts, on Culicidæ and Bombylidæ respectively, have been sent in to the press. The card catalogues of Orthoptera, Neuroptera (*sensu antiquo*) and Microlepidoptera have been kept up-to-date and parts on these groups can be issued when the material at present or lately sent out has been reported on. I have taken up the revision of the Macrolepidoptera and have included all the corrections and addenda to Volumes I, III and IV of the "Fauna" volumes on Moths, those contained in Vol. II being already mostly included in the "Catalogue of Lepidoptera Phalænæ"; probably over 10,000 entries have already been made and a good deal of literature still remains to be dealt with. This work is proceeding.

Mr. R. Senior-White has catalogued the Cecidomyiadæ, Mycetophilidæ, Bombylidæ, Trypetidæ and Sarcophagidæ during the year, and has kept up-to-date the previously completed catalogues in other families of Diptera.

The portions of the catalogue on Coleoptera and Rhynchota are in the hands of Messrs. Beeson and Andrews respectively and, as both these were away on

leave at the end of the year, I have been unable to obtain details of the work done in these Orders.

VIII. Programme of work for 1922-23.

Major.

This will follow generally on the lines of work of the current year and will include general investigations of crop-pests and especially of the pests of sugarcane, rice and cotton, of fruit-trees and stored grain.

Minor.

Results in various lines require to be written up and published as far as possible. Work and experiments in lac-culture will be continued and new insecticides and insecticidal methods tested as occasion arises. Systematic work will be carried out with our resources and the help of specialist correspondents. The Catalogue of Indian Insects will be proceeded with. Advice and assistance will be given as far as possible to Provincial Departments and to all inquirers on entomological subjects.

IX. Publications.

The following publications have been actually issued during the year ended 30th June 1922 :—

Dutt, G. R. . .	. Three new Wasps from India. (*Ind. Agric. Entl. Mem.*, Vol. VII, No. 5.)
,,	An Interesting example of Gynandromorphism in *Megachile bicolor*, Fb. (*Report Proc. Fourth Entl. Meeting, Pusa*, 1921.)
,,	*Gracillaria soyella*, Dev., and its parasite, *Asympiesiella india*, Gir. (*loc. cit.*)
Felt, E. P. . .	New Indian Gall Midges (Itonididæ). (*Ind. Agric. Entl. Mem.*, Vol. VII, No. 4.)
Fletcher, T. Bainbrigge.	Additions and Corrections to the List of Indian Crop-pests. (*Rep. Proc. Fourth Entl. Meeting, Pusa*, 1921.)

Fletcher, T. Bainbrigge.	Traps for Mosquitos. (*loc. cit.*)
,,	Note on the Oviposition of *Gynacantha bainbriggei*. (*loc. cit.*)
,,	Koenig's Paper on South Indian Termites. (*loc. cit.*)
,,	Setting Without Boards. (*loc. cit.*)
Fletcher, T. Bainbrigge, and Senior-White, R.	Surra and Biting Flies: a Review. (*loc. cit.*)
Fraser, F. C. . .	New and rare Indian Odonata in the Pusa Collection. (*Ind. Agric. Entl. Mem.*, Vol. VII, No. 7.)
,,	Further Notes on *Rhinocypha* larvæ. (*l. c.*, No. 8.)
Ghosh, C. C. . .	Supplementary observations on Borers in Sugarcane, Rice, etc. (*Rep. Proc. Fourth Entl. Meeting, Pusa*, 1921.)
Howlett, F. M. . .	Protective movements and range of vision in platypezid Flies. (*loc. cit.*)
,,	The practical application of Insect Psychology. (*loc. cit.*)
Misra, C. S. . .	*Oxycarenus lætus;* the Dusky Cotton Bug. (*loc. cit.*)
,,	*Anatrachyntis falcatella*, Stt. (*loc. cit.*)
,,	Determination of emergence of larvæ from examination of the ovaries of Lac Insects. (*loc. cit.*)
Patel, P. G. . .	Note on the life-history of *Culicoides oxystoma*, with some remarks on the early stages of *Ceratopogon*. (*loc. cit.*)
Sen, S. K. . .	Life-histories of Indian Insects. Diptera: *Sphryracephala hearseiana*, Westw. (*Ind. Agric. Entl. Mem.*, Vol. VII, No. 6.)
,,	A note on the effects of mercurous chloride on Culicid larvæ. (*Report Proc. Fourth Entl. Meeting, Pusa*, 1921.)
,,	Notes on the life-history of two species of Celyphidæ. (*loc. cit.*)
Senior-White, R., and Sen, S. K.	Further notes on the occurrence of Coleoptera in the human intestine. (*loc. cit.*)

Sharma, H. N. . . A preliminary note on the action of acids, salts and alkalies on the development of Culicid eggs and larvæ. (*loc. cit.*)

Sharma, H. N., and Sen, S. K. Oviposition in Culicidæ. (*loc. cit.*)

REPORT OF THE IMPERIAL AGRICULTURIST.

(G. S. Henderson, N.D.A., N.D.D.)

I. Administration and Training.

The writer remained in charge of the post of Imperial Agriculturist during the year under report.

Four students were under training during the period ; two were sent by the Madras Government, one from the Mysore State and one was under training for the Sugar Corporation of India.

II. Major advisory work.

The Imperial Agriculturist toured in the Punjab and examined the students at the Lyallpur Agricultural College for the College Leaving Certificate, the F. Sc. and B. Sc. degrees. A report was drawn up for the extension of cultivation at the Imperial Bacteriological Laboratory, Muktesar, after a personal inspection of the land. The Upper Shillong Farm and Dairy Herd was visited along with the Director of Agriculture, Assam.

III. Pusa farm field experiment work.

Most of these experiments are carried out in collaboration with different Sections and are dealt with in detail in the reports of the various Sections. The more important series are as follows :—

(1) *Permanent manurial and rotational experiments* were continued as before. The data obtained will be written up after the lapse of a sufficient period to eliminate seasonal variations.

(2) *Green-manuring experiments* with varying quantities of fermented sann-hemp for the Imperial Agricultural Bacteriologist.

(3) *Chilli plots* to test treatment on "die-back" for the Imperial Mycologist.

(4) *Series of manurial plots* in North Pungurbi field designed by the Fibre Expert to test the effects of the additions of various mineral substances on certain diseases.

(5) *Green fodder series.* The average result for five years is as follows :—

	Green fodder per acre in lb.
1. Math (*Phaseolus aconitifolius*)	15,779
2. Florida velvet beans	12,440
3. Cowpeas, local (*Vigna catjang*)	12,257
4. Guar, local (*Cyamopsis psoralioides*)	10,625
5. Urid (*Phaseolus radiatus*)	9,999
6. Soy beans (*Glycine hispida*)	7,836
7. Florida beggar weed	4,174
8. Val (*Dolichos lablab*)	3,055

Of these, cowpeas and *guar* are most readily eaten by the cattle.

(6) *Indigo experiments.* These are dealt with by the Indigo Section. So far, indigo sown by drill in 24″ rows and intercultivated by bullock hoes has given a higher outturn than with the usual country method of sowing.

(7) *Manurial value of meta- and pyro-phosphates.* These experiments are being carried out for the Imperial Agricultural Chemist.

(8) *Sugarcane varietal experiments.* A number of varieties are under test in collaboration with the Sugar Bureau. These include promising hybrids from Madras.

IV. Pusa Farm.

The season was a good one and the rainfall, about 40 inches, was well distributed. All the crop yields were above normal. Maize grain yielded 13½ maunds per acre

from one field, while green maize for silage yielded 300 maunds per acre. *Arhar* (*Cajanus indicus*) averaged 7·7 maunds per acre, and oats 17 maunds.

The new block of land acquired during the previous year was let to tenants on share as no money was available for development. The remainder of the farm, over 400 acres, is under a fixed rotation which is as follows :—

	1st year	2nd year	3rd year
Monsoon (*kharif*) crop . .	Maize for silage and fodder manured with farmyard manure @ 10 tons per acre or oil-cake.	Maize for corn . No manure.	Pulse, green crop, for grazing.
Winter (*rabi*) crop . .	Oats . .	*Arhar* (*Cajanus indicus*).	Oats (after application of 1 maund of superphosphate per acre).

Thus the major portion of the farm forms a fertility experiment on a large enough scale to give data of value for practical working. Estates of economical size growing general crops under direct cultivation are very rare in India. It is very much simpler to cultivate land through tenants on the share system than to run the same land by direct cultivation. It is, however, almost certain that the extension of modern dairying and pedigree stock-breeding in India will depend on the direct cultivation of fodder crops, as it will obviously be very difficult or impossible to base a dairy scheme on fodder produced by tenants. Hence the practical importance of data obtained by self-contained and self-supporting farms.

The annual yields from 13 fields of a total area of 413 acres during the last 10 years is given below.

TABLE I.

Yield from 13 fields at Pusa (413 acres) for 10 years.

Years	Oats and other cereals (grain)	Maize (grain)	Pulses, etc.	Total grain	Maize and green food for silage
	Mds.	Mds.	Mds.	Mds.	Mds.
1912-13	2,210	522	894	3,626	16,301
1913-14	1,997	200	1,100	3,297	11,513
1914-15	1,749	534	704	2,978	14,427
1915-16	2,669	884	701	4,254	36,903
1916-17	2,897	670	932	4,499	31,971
1917-18	2,376	1,276	1,010	4,662	30,893
1918-19	3,386	559	1,037	4,982	30,735
1919-20	2,479	1,064	719	4,262	31,624
1920-21	2,542	766	1,073	4,381	33,359
1921-22	3,754	1,267	1,132	6,153	34,492

During this time the yield of milk from the Pusa Herd has increased from 100,000 to 375,000 lb. per annum and the average yield per Montgomery cow per day from $5\frac{1}{2}$ to 9 lb. including dry periods during which no milk was given.

These are remarkable figures but there is no reason to believe that the limit of progress has been reached.

The commercial aspect of the farm can be measured in terms of milk and surplus stock. During the season over 375,000 lb. of milk were produced and about Rs. 10,000 worth of surplus stock sold. An expenditure of about Rs. 60,000 on the Agricultural Section, independent of salaries, provides for both the capital and revenue expenditure, and the income produced as above shows a handsome dividend on the outlay.

The Pusa Farm is heavily stocked and the main principle underlying the management of the farm is to graze the stock as much as possible on the arable land.

During the last few years, 40 acres of waste land flooded by the river during the monsoon have been levelled. This grows irrigated fodder crops during the cold weather and before the monsoon (Plate V). This fodder is of the greatest value during a scarce period and has had a valuable effect in maintaining the milk yield of the dairy herd.

V. Machinery and Implements.

The heavier part of the farm cultivation is done by the steam ploughing tackle, while many of the secondary operations are performed by tractors. Owing to the intensive rotation adopted there is very heavy work at two periods of the year, *viz.*, at the preparation for the *rabi* crops and similarly at the time of sowing the monsoon crops. Without power cultivation it would be impossible to adopt such an intensive rotation and get so much produce out of the land.

The following tables show the results of the working of the steam ploughing tackle and the tractors :—

EARLY MAIZE ON LOW-LYING LAND FORMERLY WASTE. CUT BEFORE RISE OF RIVER LEVEL.

TABLE II.

Showing cost of working the steam tackle for five seasons.

Particulars	1917-18	1918-19	1919-20	1920-21	1921-22
	No. of working days 121	No. of working days 145	No. of working days 126	No. of working days 131	No. of working days 114
	Rs.	Rs.	Rs.	Rs.	Rs.
Labour	940	934	1,200	1,450	1,243
Coal	1,424	1,656	1,623	2,140	1,622
Oil	315	482	633	588	412
Miscellaneous stores, etc., and renewals . . .	3,419	1,064	1,196	1,746	1,783
TOTAL .	6,098	4,136	4,652	5,924	5,060

TABLE III.

Showing the above costs divided into following operations per acre for five seasons.

Particulars	1917-18			1918-19			1919-20			1920-21			1921-22		
	Total area cultivated in the year	Cost per acre	Best day's work	Total area cultivated in the year	Cost per acre	Best day's work	Total area cultivated in the year	Cost per acre	Best day's work	Total area cultivated in the year	Cost per acre	Best day's work	Total area cultivated in the year	Cost per acre	Best day's work
	Acres	Rs.	Acres	Acres	Rs.	Acres	Acres	Rs.	Acres	Acres	Rs.	Acres	Acres	Rs.	Acres
Ploughing . . .	170·5	9·2	7	373·5	3·9	7·5	404·5	4·8	7·5	445	6·0	7·5	241·5	5·6	7·8
Disc harrowing . .	821·5	3·0	20	605·5	1·7	16·5	582·0	1·7	20·5	633	2·5	17·5	442·0	2·6	16·5
Grubbing . . .	616·0	4·3	26	668·0	1·4	20·5	488·0	1·6	22·0	480	2·0	22·0	600·5	2·0	21·3
Zigzag harrowing . .	11·0	2·2	...	...	...	...	...	...	...	...	...	...	...	...	...
Rolling	173·0	3·9	22	540·0	1·3	21·0	533·0	1·6	23·0	386	1·8	25·0	285·0	2·0	21·7
TOTAL .	1,792	...	...	2,187	...	...	2,007·5	...	...	1,944	...	...	1,569	...	...

TABLE IV.

Showing motor tractor details from the time each started work up to May 1922

Particulars		Fordson, June 1919 to May 1922	Austin I, Feb. 1920 to May 1922	Austin II, Jan. 1921 to May 1922	Austin III, Feb. 1921 to May 1922	Cletrac, Mar. 1921 to May 1922
Working Hours	Total	1,513	1,357	916	823	464
Ploughing	Acres	226	108	63	94	97
	Hours	430	230	189	197	157
	Acres per hour	0·52	0·47	0·33	0·48	0·61
Disc harrowing	Acres	551	543·75	485	189	318
	Hours	428	370·50	345	131	181
	Acres per hour	1·28	1·47	1·40	1·44	1·7
Grubbing	Acres	388	445·5	233	180	130
	Hours	223	278·5	161	113	67
	Acres per hour	1·74	1·6	1·44	1·59	1·94
Rolling	Acres	122	83	36	25	31
	Hours	91	52	32	20	17
	Acres per hour	1·34	1·2	1·10	1·25	1·8
Drilling	Acres	2	3·5	21	...	...
	Hours	2	3·5	13·50	...	...
	Acres per hour	1	1·0	1·55	...	...
Reaping	Acres	84	102	67	62	51
	Hours	83	108	61	64	41
	Acres per hour	1	0·94	1	0·95	1·24
Belt pulley and road haulage hours		256	314·5	111	297	...
Fuel	gal.	2,531	1,580·75	1,272	1,251	832
Engine and gear oil	,,	318	188·25	163	146	159
Grease	lb.	44	45·75	36	40	108
Waste	,,	11	17·5	17·5	16	13
Wages	Rs.	465	467	254	209	148
Cost of fuel	,,	2,376	1,868	1,420	1,376	898
Cost of lubricants	,,	1,665	736	426	524	558
Spares and repairs	,,	1,448	1,005	50	311	214
Total	,,	5,954	4,076	2,150	2,420	1,818
Cost per hour		3·93	3·0	2·34	2·94	3·9

The chief spares required were as follows :—

1. *Fordson.* Sparking plugs, coil rivets, pistons and piston rings, clutch plates, worm shaft thrust bearing, belt pulley, vapour tube, crank shaft, cylinder head, vibrator armatures.
2. *Cletrac.* Sparking plugs, piston rings, main shaft bearing, magneto and valves.
3. *Austin I.* Differential gear and pistons.
4. *Austin II.* Pistons and magneto.
5. *Austin III.* Pistons.

During the year trials were made with a 3-foot-drum all-steel threshing machine specially built for Indian conditions. This machine has been sent to the Punjab for extended trial on wheat threshing. If it proves suitable for local conditions there is likely to be a demand in future in the North-West wheat tract. Labour is getting dearer and the operations of wheat-harvesting and cotton-sowing are interfering with each other.

The usual machinery was in operation during the season and figures for all operations are carefully collected.

VI. Pedigree Dairy Herd.

The Montgomery herd and the Ayrshire-Montgomery herd were carried on the lines already fixed and the total number varied between 300—400 head. The average yield from the Montgomery cows per day was 9 lb. including the dry periods, and that of the cross-breds 15 lb. per day on the same basis of calculation.

The best half-bred cow "Alibi" gave 11,839 lb. milk in 10 months. She is in milk again and giving up to 51 lb. per day.

In the Montgomery herd all cows are being cast which do not reach 4,000 lb. per lactation after the first lactation. All lactations are calculated up to 10 calendar months.

Calf rearing. All the cross-bred calves are hand-reared as also are the progeny of the younger Montgomery cows.

Milk and grain fed to hand-reared calves per day.

	Age of calves			
	1-2 months	2-3 months	3-4 months	4-5 months
	lb.	lb.	lb.	lb.
Whole milk	10	10	5	...
Separated milk . . .	...	...	5	10
Grain mixed . . .	...	½	1	2

Out of 31 pure Montgomery calves born during the season which were hand-reared 3 died. From 63 cross-bred calves there were 3 deaths.

Cows with hand-fed calves *calve more frequently* than the others, the average figures being Montgomery cows with sucking calves a calf in 18 months, Montgomery cows with hand-fed calves a calf in 14 months, cross-bred cows a calf in 12½ months.

AUCTION SALE OF BUSA CATTLE IN FEBRUARY 1909 AT THE TIME OF THE BOARD OF AGRICULTURE

PLATE VI.

Selection work. The first heifers from the cross-bred cows by cross-bred bulls are coming into the herd and appear to be promising. On the results obtained with these animals will depend the possibility or otherwise of establishing a breed of animals with foreign blood and combining superior milk yield with the suitability to climate and immunity to disease of Indian breeds.

One outstanding fact of great practical importance to breeders has been borne out year after year at Pusa. This is the prepotency of the sire in milk production. Further data are being collected on the subject.

VII. Programme of work for 1922-23.

1. (*a*) Practical treatment of pedigree dairy herd of Indian cattle and pedigree dairy herd of Montgomery-Ayrshire cattle.

(*b*) Continuance of experiments with regard to fixing a type of Montgomery-Ayrshire most suitable to Indian conditions.

2. Practical treatment of a 1,200-acre mixed farm with particular attention to profitable modern machinery and the financial aspect of the work.

The bulk of the produce of the Pusa Farm is used for the maintenance of the dairy herd. The rotation adopted aims at the up-keep of the fertility of the land along with supply of concentrated food and long fodder and a constant supply of green fodder throughout the year.

Included in the above is the study on a practical scale of—

(*a*) Rotations.
(*b*) Crops for fodder, seed and silage.
(*c*) Implements and machinery.
(*d*) Technique of cultural operations.

3. Continuation of collection of data and results regarding the costs and capabilities of the steam-ploughing tackle on estates of this size.

4. Experiments with various types of motor tractors and ploughs, implements for collection of data and working

costs and for determination of most suitable type of tractors and implements for India. Also collaboration with manufacturers regarding the manufacturing and introduction of improvements in standard types to suit Indian conditions.

5. *Experimental work.*

(*a*) Rotational experiments.

(*b*) Trial of new varieties of crops, especially leguminous fodder crops and wheat varieties.

(*c*) Manurial experiments, especially seasonal and quantitative tests with phosphates.

(*d*) Seasonal tests with Java and Sumatrana indigo.

(*e*) Trial of sugarcane varieties suitable for growth without irrigation in collaboration with the Sugar Bureau.

6. Demonstrations, exhibitions and sales of surplus dairy stock etc., will be held from time to time as occasion offers.

7. *Touring and advisory.* Visits will be paid to provincial agricultural centres. This should tend to co-ordination of agricultural work.

REPORT OF THE IMPERIAL DAIRY EXPERT.

I

(G. S. Henderson, N.D.A., N.D.D.)

The writer held charge of the post of Imperial Dairy Expert from 1st July, 1921, till the return of Mr. Smith in December.

In July and August 1921 the writer toured in the Dharwar, Belgaum and Poona Districts of the Bombay Presidency and investigated the possibilities of various sites for the establishment of dairy herds. Full data were collected which will be useful when money is available.

Various enquiries were answered but owing to the general scarcity of money the dairy schemes projected had to be postponed. It was obvious, however, that very general public interest was aroused to the possibilities of modern dairy and creamery establishments in India and that with the return of more fluid conditions in financial circles extensive operations are likely.

Plans and estimates were prepared for the proposed Lucknow Dairy School, and a dairy scheme for the United Provinces Government was thoroughly investigated.

II

(Wm. Smith.)

1. I arrived in Bombay on return from leave on the morning of 3rd December, 1921, and immediately took over from Mr. Henderson with whom I discussed current affairs and the general position of the dairy industry in the country. Whilst in Bombay I had interviews with Mr. E. J. Bruen, Deputy Director of Agriculture for Live-Stock, Bombay, with Mr. S. K. Desai, Superintendent, Palace Dairy, Baroda, and Mr. H. J. Riddick, Assistant Controller, Military Dairy Farms, 3rd Circle, concerning

dairying and live-stock matters, and I advised the Municipal Commissioner of Bombay concerning the appointment of a special milk officer for the Corporation of Bombay. The candidate recommended by me, Mr. Zal R. Kothavala, B.Sc., N.D.D., was subsequently appointed to that post.

Before leaving Bombay I attended a meeting of the promotors of a proposed Bombay Milk Supply Company of which Mr. R. S. Patel of Mhow and Mr. Bulsari of Bombay are the principal movers, and I agreed to draw up a scheme for this company as soon as they could provide definite particulars of the land available.

2. I visited Baroda on 8th December, 1921, and had an interview with His Highness the Maharaja Gaekwar and Mr. Seddon, Joint Prime Minister of Baroda State, regarding the development of dairy-cattle-breeding in Baroda State. Subsequently a report on the enlargement of the Palace Dairy and its utilization as an educational and cattle-breeding centre was submitted to His Highness' Government along with plans of buildings, machinery specifications, etc.

3. On 9th and 10th December I attended the cattle show organized by the Government of Bombay at Charodi, Gujarat, and there discussed cattle-breeding and dairying matters with the Hon'ble Mr. Chunilal Mehta, Dr. H. Mann and the Deputy Director of Agriculture for Live-Stock. From Charodi I proceeded to Ahmedabad and visited the site of the proposed dairy farm to be established by Mr. Nariman Kothavala and advised him as to the working of such a concern.

4. I had several consultations in Calcutta and Delhi during the months of January, February, and March 1922 with members of the firm of Edward Keventer, Ltd., and Colonel A. J. Pugh regarding the establishment of a large dairy farm in the vicinity of Calcutta to supply pure milk to the city of Calcutta. The Director of Agriculture, Bengal, was present at one of these consultations. Subsequently a complete working scheme for the establishment of the proposed milk supply company was submitted to Colonel

Pugh and Messrs. Edward Keventer, Ltd., including building plans, machinery specifications, lists of live-stock, establishment rolls, and estimated profit and loss accounts.

5. At the request of the dairy farm manager, Tata Iron and Steel Co., I visited the model dairy at Jamshedpur and later on submitted a scheme to the General Manager of the company for the control of the total milk supply of the town of Jamshedpur. Machinery specification for a city milk-pasteurizing depôt was submitted along with this scheme. I also arranged for the supply of a pedigreed Saniwal bull and a wagon of 8 Sindhi cows for the Tata Iron and Steel Company.

6. In January 1922 I proceeded to Burma and inspected the proposed site for the college dairy farm at Mandalay. After a discussion on the spot with the Director of Agriculture, the Deputy Director of Agriculture, and the Agricultural Chemist to the Government of Burma, amended machinery specifications for the college dairy were submitted to the Director of Agriculture, Burma, and a report submitted to this officer on the general working and necessity for the college dairy farm.

In Rangoon I interviewed the Development Commissioner on the subject of the establishment of the college dairy and gave information concerning Indian breeds of cows to Mr. Blake, F.R.C.V.S., of the Rangoon Municipality, Mr. Rowland Ady and Mr. Mohd. Ebrahim Moola. I also discussed the question of city milk supply with Mr. E. Du Bern, O.B.E., a member of the Rangoon Municipality. Later on about the end of February I interviewed at Delhi the Hon'ble Mr. W. J. Keith, member for Burma in the Legislative Assembly, concerning the need for the establishment of the college dairy at Mandalay.

7. By request of the Principal I visited the Agricultural College, Cawnpore, in the latter part of January, and later on submitted a plan and machinery specifications for the modernizing of the college dairy there; so that the college could demonstrate to pupils and teach the pasteurization, transport and sale of city new milk supplies.

Detailed information was also sent to the Agriculturist at the Cawnpore Agricultural College regarding feed rations, the rearing and treatment of calves, etc.

8. I attended the meetings of the Board of Agriculture at Pusa in February and served as a member of the committee dealing with matters connected with dairying and cattle-breeding. I particularly made it my business to point out to the members of the Board the crying need of dairy education in this country, with the result that the Board passed unanimously a resolution recommending the immediate establishment of a dairy school at Lucknow, but owing to financial stringency Government have not up to the present been able to allot any funds for this purpose.

9. I returned from Pusa *viâ* Calcutta, and whilst there, along with the Director of Agriculture, Bengal, I interviewed the Hon'ble Minister for Agriculture, concerning the importance of the development of the cattle-breeding dairying industry in Bengal and the necessity for the appointment of a special officer of the Department of Agriculture to deal with this work.

10. Early in March I visited Karachi and, at the request of the Superintendent, Civil Veterinary Department, inspected the Willingdon Cattle-Breeding Farm, and later on submitted a report on the working of this concern with plans of the necessary buildings required and lists of utensils, with estimates of cost of the necessary live-stock, buildings, and utensils required to bring this undertaking up to the standard of modern practice and place it on a sound business basis.

11. Whilst at Karachi on this and a subsequent visit the following cattle were selected and despatched to the persons or Governments indicated. All animals selected in milk were milked for two days in my presence and the yield of each animal recorded.

	Cows	Bulls
Ed. Keventer, Ltd., Calcutta . . .	8	0
Agricultural College, Cawnpore . . .	16	2
Imperial Bacteriological Laboratory, Muktesar	8	0

	Cows	Bulls
Military Dairies, 1st Circle . . .	12	0
Agricultural Department, Bengal . .	7	1
Corporation of Calcutta	0	4
Mr. Rowland Ady, Rangoon . . .	16	0
Agricultural Department, Burma . .	11	1
Agricultural Department, Central Provinces	8	0

12. I attended the sale of pedigreed Saniwal bulls held at the Military Dairy Farm, Ferozepore, on 11th March, 1922, and there selected and purchased bulls for Colonel A. J. Pugh, Calcutta, The Tata Iron and Steel Co., Ltd., Jamshedpur, the U. F. C. Mission, Jalna, and Mr. J. R. Patel of Mhow.

13. On the invitation of the Officer-in-charge, Government Oat Hay Farm and Cavalry Runs, Okara, I visited that station, and in company with this officer visited many villages in the Okara district and discussed with the cultivators the general cattle-breeding dairying situation. I also advised this officer as to the best methods of encouraging dairying amongst his own tenants and of advancing the industry in his district.

14. From Okara I proceeded to the Agricultural College, Lyallpur, and by arrangement with the Principal gave two lectures to the students there, one on the importance of milk production in connection with cattle-breeding and the other on the urban milk supply in India. Both these lectures were followed by discussions in which the students freely took part. Later a plan and specification of a suitable milk pasteurizing and cooling plant for demonstration purposes was submitted to the Principal of the Lyallpur College.

15. Accompanied by the Superintendent, Civil Veterinary Department, Lahore, and the Assistant Controller, Military Dairy Farms, 2nd Circle, I visited on 18th March the farm of Chowdri Jehangir Khan at Jehangirabad near Kutcha Khu and there inspected his very fine herd of Saniwal cattle. Whilst at this farm I selected ten cows in milk for Colonel Pugh of Calcutta.

16. In April I visited Poona and discussed with the Deputy Director of Agriculture for Live-Stock, Bombay, the establishment of cattle-breeding farms and the distribution of premium bulls in the presidency. It was hoped that on this visit I would be able to give evidence before the Special Cattle-breeding Committee then sitting in Bombay Presidency, but, owing to causes over which I had no control, the Committee could not meet at this time and my evidence was given at a later date in the current official year.

17. During May and June I paid three visits to Simla and discussed the policy of this section of the department with the Hon'ble Member for Revenue and Agriculture, the Secretary of the Revenue and Agriculture Department, and the Agricultural Adviser to the Government of India. I also had the opportunity of discussing the general question of dairy development in the Punjab with the Director of Agriculture in that province.

18. Arrangements were made whereby the dairy manager of the new State Dairy of His Exalted Highness the Nizam of Hyderabad was permitted to go to the Military Dairy Farm, Bangalore, for experience and training.

A correspondence took place with the Foreign Minister, Dewas State (Junior Branch), regarding the development of the dairy industry in that State, and I have arranged to visit that State at an early date and submit later a complete scheme for their requirements.

The Honorary Co-operative Organizer, United Free Church Mission, Jalna, Hyderabad State, wrote asking advice and assistance in connection with the organization of co-operative dairy societies amongst his people, and I have arranged to visit Jalna later on and give all assistance possible.

19. In reply to a series of queries from the Colonial Secretary, Mauritius, plans of standard types of cattle sheds and particulars as to yields, cost and general appearance of certain breeds of Indian dairy cattle were furnished.

20. The Commissioner, Bombay Municipality, on his recommending for appointment as Special Milk Officer the

man recommended by me, stipulated that this office should advise and assist this new officer, the first of this kind in India, as much as possible, and since Mr. Kothavala's appointment as dairy expert to the Corporation of Bombay I have been in close touch with him and amongst other information have provided him with :—

(*a*) A note on the milk supply problem of Bombay recommending the subsidizing by the Municipality of approved modern dairy companies producing milk on dairy farms in the country and railing it after pasteurizing into Bombay, the subsidy to take the form of guaranteed interest on capital for a term of years.

(*b*) Plans of standard cow-sheds.

(*c*) Plan of a city milk pasteurizing depôt with machinery specifications suitable for same.

The Bombay Corporation are taking an active and intelligent interest in the city milk supply problem, and this office is doing and will continue to do everything possible to assist them : schemes are now being drawn up by me for two financial groups based on interest being guaranteed by the Corporation of Bombay for ten years at $5\frac{1}{2}$ per cent.

21. In response to an enquiry from the Principal, Agricultural School, Bulandshahar, plans of cattle shed, dairy building with wash-up room and boiler room, silo tower, and milk-recording room, were supplied to that officer, and cattle shed plans were also supplied to Mr. V. E. Coapman, A. P. Mission, Moga, Ferozepore District. Machinery specifications and list of utensils necessary were supplied to the Assistant Registrar of Co-operative Societies, Madura, for a co-operative dairy society established there. Replies to a long list of queries sent by the Municipality of Quetta, Baluchistan, regarding the establishment of municipal cattle sheds outside the town area were furnished.

22. In addition, enquiries asking for assistance from 25 correspondents were received during the year.

23. Definite enquiries were made at this office for information as to where advanced dairy technical knowledge could be obtained in India for no less than 18 suitable candidates. Some of these were advised to proceed to Europe in order to obtain the desired education, but the majority were advised to wait as it was hoped that the Government would shortly do something in the direction of providing a modern dairy college in some part of India. In view of these enquiries and the absolute impossibility of really developing the dairy-cattle-breeding industry in India without a sound organized system of dairy education, in May I went specially to Simla to interview the Agricultural Adviser to the Government of India and to see if any means could be found of solving this problem bearing in mind the present financial position of Government, and after a lengthy discussion I applied to the Government of India to hand over the administration and control of military dairy farms in India to the Imperial Agricultural Department, so that in addition to their present function of providing dairy produce to the Army these institutions scattered through the length and breadth of India should be utilized as educational centres, as demonstration dairies and as bull-breeding farms. All the information and advice this office may give on dairying matters can be of little avail unless Government provide some satisfactory system whereby the people of this country can be given the necessary training to work schemes prepared on my advice, and by which general knowledge of dairy-cattle-breeding can be disseminated not only to the agriculturist but to the public at large. I may repeat what I said in my last year's report that the crying need of this country is dairy education. We cannot even organize the industry without trained men. India can no more do without milk and milk products than she can do without water. All classes of the community need milk and its products. As things are now the great mass of the poorer people cannot afford to buy either pure milk or pure *ghi* (clarified butter). It is and it ought to be my work to so develop the industry that even the poorest

will be able to get pure milk and pure *ghi*. This desirable end can only be achieved by education and organization. We cannot even touch the latter without the former, and with the country's finances as they are now there appears to be only one direction in which we can look for the educational facilities we require, *i.e.*, the existing military dairy farms.

24. An article written by me on "Cow keeping" was published in the January (1922) Number of the *Agricultural Journal of India*.

REPORT OF THE SECRETARY, SUGAR BUREAU.

(Rao Saheb Kasanji D. Naik, M.A.)

Mr. Wynne Sayer continued in charge of the office of Secretary, Sugar Bureau, up to 23rd March, 1922, when he went home on eight months' combined leave and I was appointed to officiate for him. There was no change in the office staff.

The term of the Bureau which still continues on a temporary footing was limited to 31st March, 1922, or up to such time as the Government of India passed definite orders on the recommendations of the Indian Sugar Committee, whichever was earlier. As it was understood that the Government would be unable to take any action on the Committee's recommendations before 31st March, 1922, sanction was obtained for the extension of the term of the Bureau for another year, *i.e.*, up to 31st March, 1923.

The main work of the Bureau which is to collect information relating to the sugar industry in all its aspects and to make it available to the public was continued during the year. Besides this, the Bureau continued to develop its work on the agricultural, industrial and commercial sides of this industry. A brief description of these activities is given below :—

I. Agricultural.

The work on the agricultural side consists in the (1) arranging for mill trials to ascertain the behaviour under mill conditions of the canes which have been found satisfactory as field crops with a view to find out whether the higher sucrose content, etc., shown in chemical analysis under laboratory conditions are realized in the factory, and (2) the rapid multiplication of the canes of proved superiority for distribution among large sugarcane growers.

It may be mentioned at the outset that the soil at Pusa is fairly representative of the soils in North Bihar where the sugar industry is increasing in importance. There are no

less than nine modern factories working in North Bihar and the area under cane in the four districts of Darbhanga, Muzaffarpur, Champaran and Saran is 128,700 acres. The Bureau is therefore very favourably located in the heart of the sugar factory industry which is more likely to take immediate advantage of the results of its experimental work on sugarcane, and further there are numerous large sugarcane growers in North Bihar who are keen on increasing their yields of cane.

The work is being done in close collaboration with the Imperial Agriculturist who has kindly given all facilities to the Sugar Bureau in conducting these important experiments. As a result of the work done on this crop in previous years a standard method of cane cultivation directed towards improving and simplifying planting operations has been evolved at Pusa.

During the year under review, the following 20 varieties were grown on a plot of 9·34 acres :—

Exotic. Java 36.

Coimbatore seedlings. Nos. 210, 213, 214, 220, 221, 224, 225, 227, 228, 231, 232 and 233.

Local canes. Hemja, Reora, Saretha, Maneria, Kuswar, Yuba and Mungo.

The average yield per acre through all varieties was 574 maunds valued at Rs. 287 and the total expenditure per acre, including cost of all agricultural operations, manure, etc., came to Rs. 191.

The manuring given is purposely kept very low as it is desired to test all canes thoroughly under conditions similar to those they are likely to meet in the district. The results of tests carried out so far have shown the Coimbatore seedlings 210, 213, 214 and 221 to possess qualities admirably suited to Bihar conditions. They have a deep-rooting system with good drought-resisting qualities, appear to respond to manuring and cultivation better than the local canes and give a higher tonnage. Further, as compared with the local cane Hemja which is a late ripener, two of

these Coimbatore seedlings, Nos. 213 and 214, are early ripeners as the following analysis will show :—

Analysis taken on the 29th November, 1921.

Description of the samples	Average weight of a cane in lb.	Juice per cent.	In juice			
			Brix	Sucrose per cent.	Glucose per cent.	Purity per cent.
Co 213 . .	1·640	62·42	15·37	12·14	1·57	78·99
Co 214 . .	1·076	58·67	17·67	15·19	0·64	85·97
Hemja . .	1·174	55·15	12·26	9·16	1·22	74·68

Analysis taken on the 16th January, 1922.

Description of the samples	Average weight of a cane in lb.	Juice per cent.	In juice			
			Brix	Sucrose per cent.	Glucose per cent.	Purity per cent.
Co 213 . .	1·807	64·02	17·89	16·00	0·53	89·45
Co 214 . .	1·250	59·68	19·45	17·13	0·30	88·08
Hemja . .	1·250	49·39	14·21	11·64	0·75	81·94

As an early ripening cane with good tonnage is a great desideratum of the sugar factories who get only unripe cane for crushing in December, steps were taken to multiply these canes for seed purposes according to the Java method of growing to six months and then cutting them for sets and replanting. A half-acre plot was grown under irrigation in February which gave enough planting material for nearly $4\frac{1}{2}$ acres in July. The planting of cane in July in this part was altogether a new thing but it succeeded admirably and enough material from this July-sown plot was available for planting 27 acres in February 1922. This method for the rapid multiplication of a desirable variety having succeeded, a further step was to ascertain the milling qualities of these superior Coimbatore canes under factory conditions. For conducting such a bulk test it is necessary to grow cane on a large area. Accordingly in February 1922, some 25 acres

were planted with Coimbatore seedlings 210, 213, 214 and 221. They have stood the trying hot weather successfully and are free from disease and their growth is all that can be desired.

These canes have already impressed the large sugarcane growers of Bihar and they are willing to give these varieties a trial. To supply the large quantities of planting material required for distribution among them it is however necessary to grow some 60 acres of cane for seed purposes, and it is gratifying to note that the large sugarcane growers of Bihar have voluntarily come forward to meet the whole cost of growing these canes for distribution among them.

Several new seedlings from Coimbatore were received during the year and these have been planted up in small nurseries for rapid multiplication. Some of these are likely to turn out superior to the seedlings already being grown, and it is the aim of this Bureau to keep itself well stocked with new varieties so that when any seedling is found to have deteriorated, its place can be readily taken by a new cane better than the previous one.

It has been mentioned in previous reports that nine of the latest Java varieties were brought by the Secretary, Sugar Bureau, in the year 1920 and sent to Coimbatore for trial. Of these, E. K. 2 and E. K. 28 which are thick canes are rapidly increasing in cultivation in Java. Hence as soon as sufficient planting material is available at Coimbatore it is proposed to distribute these canes to the main sugarcane farms in the tropical parts of India to ascertain whether they retain their superiority under Indian conditions and, if so, whether they are likely to enter into general cultivation. Two P. O. J. Nos. 1410 and 1499 are doing well at Coimbatore, the first being the most vigorous of the whole lot. It is a free grower and possesses the deepest root system of all. Even in a season of very poor arrowing, this cane flowered and showed open healthy anthers. The other P. O. J. also grows freely but has a moderately deep root system. Both have been found to have

a very satisfactory habit though in the point of tillering they are distinctly inferior to some of the typical North Indian canes. It is proposed to distribute them for testing on the main cane farms in the provinces.

II. Industrial.

The Bureau continued to be in touch with all sugar factories in India. Returns for the working season of 1920-21 were furnished by all and we were thus enabled to publish notes on the total production of refined sugar in India by modern methods in the issues of the *Indian Trade Journal*, dated 1st December, 1921, and 27th April, 1922, and the *Agricultural Journal of India*, Vol. XVII, Pts. 1 and 4.

Touch was maintained with sugar machinery manufacturers in Great Britain and the United States of America, and the correspondents who seek the advice of this office were kept informed of the reductions in the price of machinery that took place during the year. Numerous enquiries about sugar machinery and about the cost and equipment of the minimum size of a factory were received during the year and dealt with in consultation with Mr. William Hulme. The Secretary, Sugar Bureau, was also freely consulted by the Director of Industries, Bihar, in the matter of a pioneer sugar factory proposed to be started in South Bihar.

The raising of the import duty from 15 to 25 per cent. *ad valorem* during the year and also the increased railway freight rates have naturally created more interest in the local production of sugar. But on account of the stringency in the money market and the high price of machinery, combined with a lack of suitable blocks of unoccupied land in areas where land and labour would be available at reasonable rates to enable the factory to grow its own cane, the development of the sugar industry in this country is not expected to be rapid. There is, however, no doubt that progress is being made as will be seen from the number (9) of new joint stock companies for sugar manufacture registered during the year. Further, as a result of the large

profits made by the factories during war time most of them have been enabled to carry out large additions and alterations with a corresponding increase in their efficiency.

Mentions was made in last year's report of a small four-roller power-driven mill embodying some novel features sent for trial from Hawaii. This mill was received during the year and on trial was found to work well with the Fordson tractor. The rollers took the full feed and easily dealt with the heavy fibre cane. There were no stoppages and the wooden foundation fitted to the mill enabled it to work with perfect steadiness. Its extraction figures were also satisfactory. The canes dealt with were the local Hemja and J. 36. With a view, however, to have a thorough test made and to see how it deals with soft thick cane, it has been arranged to send the mill to the Bengal Department for trial at Dacca next season.

Owing to enquiries for trained men a register has been opened for men seeking employment as works chemists or managers, agricultural superintendents for sugar estates, etc., whose names and qualifications are brought to the notice of the factories whenever a vacancy is reported.

III. Commercial.

It was mentioned in last year's report that the Bureau in order to assist the sugar trade in India publishes every week in the *Indian Trade Journal* statistical notes bearing on the production and consumption of this commodity in the principal sugar-producing countries of the world and the rise and fall in the world's price of sugar. During the year under review this practice was continued. The notes contributed were so much appreciated by the sugar firms in India that a desire was expressed that the Sugar Bureau should add to this side of its activities and give more up-to-date information by arranging to get regular cables regarding the crop conditions and market reports from the principal sugar centres of the world. Accordingly a meeting of the sugar importers and manufacturers was held at

Calcutta on the 12th August, 1921, under the presidency of the Director-General of Commercial Intelligence, and a resolution was passed that while the practice of contributing notes to the *Indian Trade Journal* should be continued, the Sugar Bureau should take early steps to establish for a trial period of six months a cable service of the nature indicated above, the cost being met by the firms joining the scheme. With the approval of the Government of India this service was started in January 1922. Leading sugar importers and manufacturers from Calcutta, Bombay, Madras, Karachi and Cawnpore have joined and an organization has been built up of correspondents and agents not only in the principal Indian markets but also in Java, Mauritius, Cuba, Porto Rico, United States of America, United Kingdom and Holland. The service has proved useful to the trade and its working by the Sugar Bureau has been considered highly efficient. The result has been that at the end of the trial period of six months the members unanimously recommended that the service should be continued for a further period of six months on a self-supporting basis and the Government of India have sanctioned its continuation. Incidentally the Telegraph Department benefits to the extent of Rs. 15,000 extra business.

The Bureau is now looked upon as a really live institution to be consulted for up-to-date information regarding the sugar crop and market conditions in the principal sugar producing and consuming countries of the world. It was generally recognized that for this service to be really useful it should be conducted by a Government Office whose business is in connection with sugar.

IV. Miscellaneous.

Library. During the year under report 463 volumes were added to the library either by purchase, exchange or free supply. The catalogue of books and periodicals in the library which was mentioned in last year's report as having been sent to the press will soon issue. It is proposed

to distribute copies to all the Directors of Agriculture and Industries in the provinces, special workers in the sugar line and institutions where such catalogues are likely to be required for reference.

Museum. A museum is being maintained in which samples of various grades of sugar manufactured by each factory in India are renewed every year. During the year under report samples of *gur* manufactured in the principal cane-growing tracts of this country were obtained for exhibition in the museum.

Publications. It has been mentioned above that this Bureau contributes notes dealing with the statistics of sugar production and consumption and sugar market conditions in the principal countries of the world. One hundred and forty-three such notes were published during the year. It is needless to mention that the sugar trade in India find them useful, as they usually refer to the notes in asking for further information.

Nine notes were also contributed to the *Agricultural Journal of India.* Besides these, the following two articles were published during the year :—

Naik, K. D. . . The World's Sugar Situation in 1920 and the Present Position. (Supplement to the *Ind. Trade Jour.*, dated 6th Oct., 1921.)

Sayer, W. S. . . A Review of the Sugar Trade in India during the calendar year 1920. (Supplement to the *Ind. Trade Jour.*, dated 25th Aug., 1921.)

V. Conclusion.

As this Bureau is the only organization which attempts to supply information as far as possible on all sides of the sugar industry, its help is freely sought not only by Provincial Departments of Agriculture but also by the general public. Sugar importers and manufacturers are freely availing themselves of the assistance which the Bureau is in a position to render. This has entailed a heavy increase

in the correspondence work which the small staff of the Bureau has hitherto been able to manage by working at high pressure.

The Bureau deeply regrets the death of Mr. William Hulme to whom it has been much indebted for assistance rendered as a Consulting Sugar Engineer.

Acknowledgments are due to the Director-General, Commercial Intelligence, for the valuable help given in connection with the cable service and in making the work of the Bureau known to the business world, to the Imperial Agriculturist without whose active co-operation it would have been impossible to carry out the large scale experiments on the testing of Coimbatore seedlings that we are conducting at Pusa, to the Imperial Agricultural Chemist for the assistance given in the testing of the Honolulu iron mill and for the various chemical analyses carried out by him, and lastly to the Director of Statistics for furnishing information of a statistical nature whenever required.

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